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Fraunhofer Wilhelm-Klauditz-Institut Holzforschung

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Glue-laminated timber...

… a high-grade, ecologically sound material with favorable disposal properties

1 Introduction

Wood is a traditional construction material still widely used today, particularly for single- and two-family homes, kindergartens, school pavilions, and other small to medium-sized buildings, but also for sports facilities as well as warehouses and industrial structures. The sustained use of wood in construction is due not only to traditional reasons but also to the excellent technical characteristics of this material. Wood features outstanding strength values with a comparably low weight. **Fig. 1** illustrates this on the basis of strength/density ratios in comparison with other materials such as steel, aluminum, and concrete. Moreover, it is convenient and easy to process and – due to sustainable forestry – also available in sufficient quantities and good qualities in this country. In the past decades, the development of new wood products significantly expanded the material's range of applications in the construction industry. In plane applications, panel materials such as plywood, particleboard, and more recently OSB (oriented strand board) have established new standards. In structural applications, builders often rely on glue-laminated timber (gluelam), solid structural timber, laminated beams, and, for some time now, further homogenized wood products (engineered wood). These wood-based materials are characterized by dimensional stability as well as high strength values and moduli of elasticity that can be reliably calculated. For this reason, even very large wood structures such as bridges and halls can be built with these materials. Using gluelam as an example, the following deliberations will illustrate, beyond the engineering advantages, that the new wood products also feature outstanding ecological properties and as a rule lend themselves well to end-of-life disposal according to the provisions of the Closed Substance Cycle Waste Management and Disposal Act (KrW-/AbfG) of 1996.

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2 Material composition

As the name implies, gluelam consists of wooden boards that are glued together along finger joints to form beams. The individual boards or strands are usually spruce, but other coniferous woods can be used as well. As a rule, the strands are 33 or 42 mm thick, but depending on the application, the thickness can also vary from about 20 mm to as much as 45 mm. After they have been dried to a mean moisture content of 10%, the strands are assembled to gluelam with approved adhesives. The companies that handle these operations must be licensed adhesives processors. The following adhesive types are permissible:

- Urea resin and melamine resin glues,
- Phenol resorcinol adhesives, and
- Polyurethane adhesives.

Urea resin bonding is suitable for applications in relatively dry zones (temperature <50°C), especially indoor uses; the other adhesives are also approved for outdoor applications. The technological characteristics of gluelam are governed by DIN 1052. Beyond these generally binding requirements, gluelam is also available in enhanced qualities that are subject to the provisions of the RAL seal of quality for laminated wood products. In certain applications, gluelam must also fulfill special requirements related to wood and fire protection. However, following the latest developments in construction engineering, these requirements

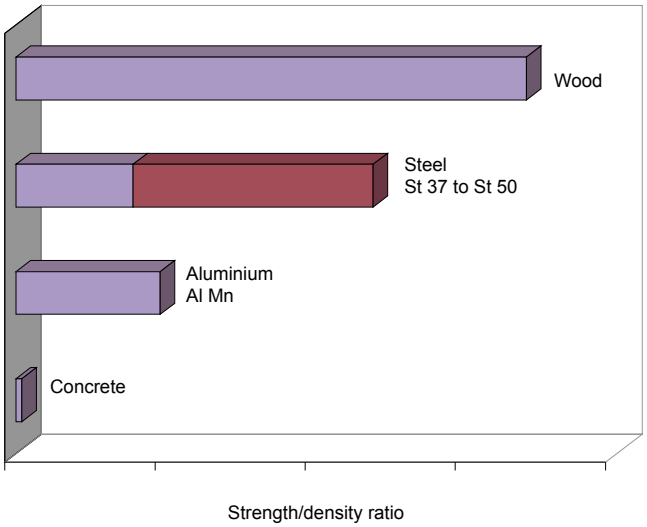

Figure 1: The strength/density ratio of various construction materials

are fulfilled primarily with design measures and only to a subordinate degree with chemical treatments. For this reason, the treatment of gluelam or the pretreatment of the strands with chemical agents is the exception today, and even in the exceptional cases, the manufacturer must provide evidence that the agents are unobjectionable from an ecological and medical point of view. The agents used must be approved by the German Institute of Construction Technology in Berlin.

3 Ecological properties

Wood is a renewable resource and raw material. It is produced in forests that in Germany have been sustainably managed for over 200 years, i.e. the annual harvest is never higher than annual growth. In fact, incremental growth in Germany for many years has been perceptibly higher than the amounts harvested. Thus, at least in Central Europe, there is no longer a shortage of wood. Moreover, more and more woodlands were converted from monocultures into species-diversified forests during the past two decades. Unlike other materials, wood is thus extracted very ecologically from the ”wood factories” known as forests. Many of the other ecological factors are advantageous as well. Wood can be harvested, machined, and processed with little energy. The by-products generated in sawmills where beams and boards are manufactured are valuable raw materials for the chipboard and fiberboard industries. Other production wastes such as sawdust and bark can be composted or used to generate energy. The utilization of wood is therefore a role model of a closed substance cycle.

These ideal characteristics of wood can be numerically verified with great precision in ecobalances. Thus, the global warming potential of lumber expressed in kilogram carbon dioxide equivalents, is negative, unlike that of other materials. In other words, the manufacturing process binds more carbon dioxide than it releases **(Fig. 2)**. The same applies to gluelam. The model of the energy balance for the production of 1 cubic meter of gluelam from 2.48 cubic meters of solid spruce delivers an energy surplus if the residual wood is converted into energy with power/heat cogeneration **(Fig. 3)**. Compared with other structural materials such as steel, aluminum, or concrete, wood thus stands out with significant ecological advantages.

4 Emissions

The fragrance of freshly manufactured gluelam, which most people find pleasant, is due to natural resins present in coniferous woods and soon dissipates. The adhesives used in the manufacture of gluelam are solvent-free. In gluelam, there is no emission of volatile organic compounds (VOCs) other than coniferous resins. Even the substances used in polymer adhesives are non-volatile and are rendered inert when the resins condense. Only formaldehyde may escape from certain adhesive resins, but here, too, the emission values of modern adhesive systems are low and hardly exceed those of untreated wood. If the adhesive is professionally applied, the emissions are clearly below the limits specified by law. **Gluelam manufactured with formaldehyde-free polyurethane adhesives is fully comparable with natural solid wood in this respect.**

Today, water-based systems are available for applications in which the surfaces of gluelam products are coated with a transparent finish or must be protected against water and dirt. Natural varnishes or waxes are also suitable finishing and protection systems, but they may contain solvents such as turpentine or white spirit. When finishing systems of the latter category are used, a thorough ventilation of the structural elements and processing rooms for several days is recommended after the surface treatment.

5 Disposal

As a rule, structural elements have long service lives. Therefore, the disposal issue is less crucial here than in the case of wood products that are used only for short or medium-term durations, for instance crates, pallets, cable drums, etc. Nonetheless, the disposal issue will be reviewed here, again using gluelam as an example.

Recovery can pertain to substances or energy. Removal basically covers thermal treatment in waste incineration plants or storage in landfill sites.

5.1 Substance recovery

The key channel for substance recovery in the case of gluelam at the end of its life span would be deployment in the chipboard

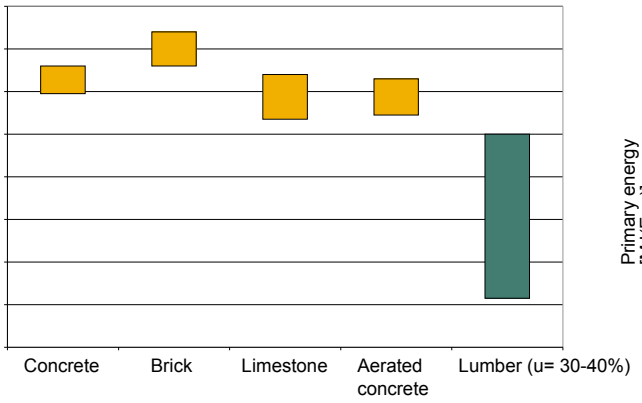

Figure 2: Global warming effect (GWP 100) in kg CO^2-equivalent for the preparation of, in each case, 1 m^3 of material (according of SIA 1995, R & D of Limestone 1995, Wegener and Zimmer 1997).

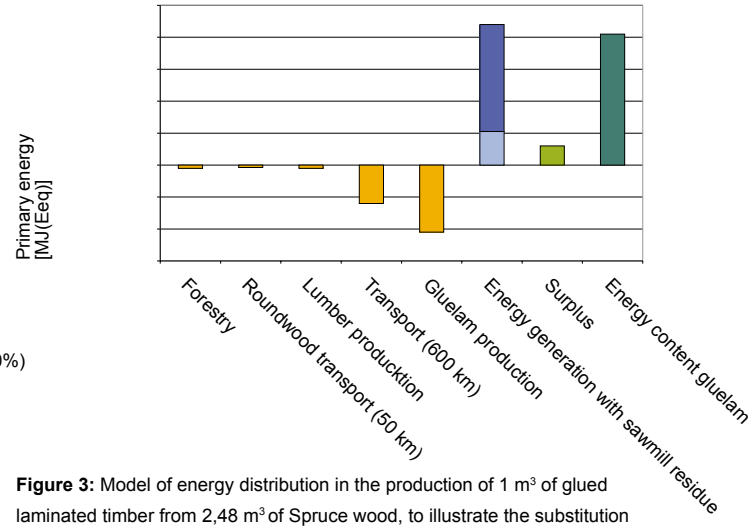

Figure 3: Model of energy distribution in the production of 1 m^3 of glued laminated timber from 2,48 m^3 of Spruce wood, to illustrate the substitution potential available in timber production (Wegener and Zimmer 1999).

and fiberboard industries. The small amounts of adhesives and coatings (<3% of the total mass) are marginal when the wood is recycled this way. Certain restrictions would apply if the wood had been treated with preservatives, which is very rare, or if the wood substance had been damaged by use. Additionally, gluelam at the end of its life span could be chopped and then composted. The nitrogen-based urea resins would act as activators for the microbiological decomposition reactions. The other binding agents are inert and transformed into humus-like substances. Disposal is a generic term that includes the recovery and removal of waste.

5.2 Energy recovery

The meaningfulness of energy recovery are even greater than that of substance recovery methods. Gluelam is a fuel comparable to untreated wood; it is dry and therefore has a high calorific value. It is approved for use in commercial combustion systems in the woodworking and lumber industries. It does not generate any harmful emissions such as hydrogen halides and heavy metals.

Even treated gluelam can easily be used for energy recovery in combustion systems that comply with the 17th Federal Emission Control Ordinance. It is not necessary to dispose of gluelam wastes in waste incineration plants. Currently, the storage of used gluelam in landfill sites would be attractive from a cost point of view, but this is not very sensible in ecological terms. When TA Siedlungsabfall (Germany's technical directives governing the disposal of household wastes) becomes effective in 2005, landfill disposal will no longer be an option.

6 Summary and outlook

Gluelam is an excellent structural material which has significantly expanded the scope of applications for wood in the construction industry. Its ecological characteristics are comparable with those of solid structural timber. At the end of its life span, it can be used for substance or energy recovery. Certain limitations apply only to gluelam that has been treated with preservatives, a case which rarely occurs in practice. It is not necessary to dispose of used gluelam in waste incineration plants.

7 Recommended literature

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