HARDWOOD GLULAMS – EMERGING TIMBER PRODUCTS OF SUPERIOR MECHANICAL PROPERTIES

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ABSTRACT: The paper reports on the recent state of hardwood glulams technically approved in Europe and/or Germany for load bearing structures. Build-ups, mechanical properties, manufacturing specifics and issues related to strength equations including size effects are discussed. The high potential of this emerging structural timber product group is herein also revealed.

KEYWORDS: Hardwood glulam beams, dark red Meranti, white oak, chestnut, structural beech timber, beech LVL, lamination effects, strength equations, manufacturing requirements

1 INTRODUCTION

The driving forces for an increased attention in Europe towards glued laminated products made of hardwoods stems from several facts, the most important being: i) noticeable shortage and rapidly rising costs for softwoods, ii) high stocks of structurally so far not used hardwood resources in Central and Southern Europe and iii) a continuous shift in re-afforestation policies towards hardwoods due to better aptness of several broadleaf species versus soil and climate conditions.

From a technical point of view, hardwoods represent a far more heterogeneous group of timber species which in most cases show higher densities, with a range of about 550 to 950 kg/m³ for Northern hemisphere hardwoods such as beech, oak, chestnut, ash and certain Eucalypts. The higher densities imply several consequences. On the one hand considerably increased strength and stiffness properties are obtained. On the other hand the manufacture of durable bonds is a far more delicate task as compared to softwood gluing. Further, the natural durability of hardwoods reveals an even larger scatter as compared to softwoods with respective consequences on the climatic use conditions of the engineered products. Within the last decade, at a considerably increasing rate, several national and European technical approvals for glulam made of different hardwood species have been issued. The latest approved hardwood glulam is produced from beech LVL. The paper reports on build-ups, manufacture, mechanical properties and some issues of underlying strength equations.

2 HARDWOOD GLULAMS WITH GERMAN AND/OR EUROPEAN TECHNICAL APPROVALS

So far the use of almost all below mentioned hardwood glulams is limited to climate service class (SC) 2, conforming to sheltered outdoor conditions, whilst glulam from structural beech laminations is confined at present to SC 1 (heated indoor) due to issues of natural durability and expressed shrinkage-swelling properties.

2.1 GLULAM FROM DARK RED MERANTI

The first known technical approval for hardwood glulams in Europe has been issued on a national basis by the German Building Authority, DIBt, in 2004 [1] for glulam made of the tropical hardwood species Dark Red Meranti (Shorea pauciflora). The cross-sectional sizes of the beams are limited to a width and depth of 55 ≤ b ≤ 150 mm and h ≤ 320 mm, respectively, with a maximum beam length of 6 m. The finger jointed laminations with a thickness of 20 mm are built up of very short board sections with a minimum length of 150 mm. The density of the rather defect free timber, graded otherwise as class LS10 according to DIN 4074-5, must also be in the range of 400 to 650 kg/m³. The strength class of the beams was limited in a first very conservative approach to GL28h, corresponding to the strength and stiffness profile as specified for the same softwood GLT class defined in EN 14080. The product, manufactured in East Kalimantan, Indonesia, has been successfully used for more than a decade without known deficiencies.
2.2 GLULAM FROM BEECH

The cross-sectional beam depths comprising minimally three laminations are at present restricted to 600 mm.

2.2.1 SOLID TIMBER LAMINATIONS

The second hardwood glulam product, then introduced in 2009 via a German technical approval [2] was glulam made of structural beech timber. The high strength and stiffness properties of beech wood have been long known but were utilized only in rare cases. The approval based on either visually graded (LS10, LS13) or visually-mechanically assisted graded (MOE by vibration) laminations (thickness 30 mm, width ≤ 150 mm) allows for homogeneously and non homogeneously built-up glulams with a characteristic bending strength of up to 48 MPa, hence exceeding the strongest softwood glulam strength class GL 32c by a factor of 1.5. An MOE of 15.1 GPa is also obtained.

2.2.2 LVL LAMINATIONS

The most recent development in glulams based on hardwoods is manifested by GLT built up from laminations of beech LVL, representing a brand new product with superior strength values (f<sub>l,0,k</sub> = 70 MPa) to be introduced in the building sector in the second half of 2014. The employed beech LVL laminations without finger joints have a thickness of 40 mm and width ≤ 300 mm. The approved glulam bending strength is 70 MPa for the reference size of 600 mm and may be increased up to 77 MPa at 300 mm. The characteristic reference (h = 120 mm, i.e. 3 laminations) compression strength parallel to fibre for service (climate) class 1 is 59.4 MPa, which by a linear lamination effect law can be increased maximally to 70 MPa for h ≥ 320 mm, i.e. 8 laminations. The stated ultra-high compression strength level, which is 3 times higher than the strongest softwood glulam strength class, gives way to new possibilities for timber competing with high strength concrete.

2.3 GLULAM FROM WHITE OAK

In 2013 German and European Technical approvals were issued for two different white oak (quercus petraea, quercus robur) glulam products. Both brands differ considerably with regard to cross-sectional dimensions, build-ups and timber source. The strength and stiffness properties for the regular build-ups with finger joints are comparable (see Tab. 1). VIGAM oak glulam [4], with timber from France, is approved for cross-sectional widths and depths of b = 50 – 160 mm and h = 80 – 400 mm, respectively; laminating thickness of 20 ± 2 mm and a beam length of ≤ 12 m. The cross-section is built up symmetrically inhomogeneous from lamination grades LS10 and LS13 acc. to DIN 4074-5.

Schiller oak glulams [5] with timber laminations (thickness:19 -23 mm) from Germany and Czech Republic comprise considerably smaller cross-sections of b = 50 - 70 mm, h = 76 - 280 mm, and are primarily used for posts and beams in facades. The build-up is homogeneous; lamination grade LS13+ (= LS13 acc. to DIN 4074-5 and knot diameter ≤ 7mm); and density is given as between 600 – 750 kg/m³. The premium build-up as compared to the standard build-up has no finger joints in the outer tension laminations in bending.

The bending strength of the laminations of the oak grades LS10, LS13 and LS13+ acc. to [4] and [5] must be ≥ 38, 47 and 80 MPa for the unjointed laminations and ≥ 49, 51 and 60 MPa for those with finger joints. Table 1 reveals that finger jointed VIGAM and Schiller build-ups provide characteristic bending strengths (5%-quantiles) and mean MOE’s closely matching the values of the highest European-standardized softwood glulam strength class GL32c. However, compression strength parallel and perpendicular to grain are almost 2 times and 3-4 times higher, respectively, as compared to GL32c.

**Table 1:** Mechanical properties of oak glulams [4; 5] and for softwood glulam GL32c acc. to EN 14080.

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<td>650</td>
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<sup>2)</sup> no finger joint in outer laminations, <sup>3)</sup> valid for SC1; in SC2: f<sub>c,0,k</sub> 2/3

REFERENCES

[1] Z-9.1-577 (2010): German techn. approval “Glulam from Dark Red Meranti”; issued 1<sup>st</sup> 05.04.04; holder: Enno Roggemann, Bremen, Germany


[4] ETA-13/0642 (2013): European techn. approval “VIGAM-Glued laminated timber of oak”; issued 1<sup>st</sup> on 02.03.2013; holder: Holz Schiller, Regen, Germany