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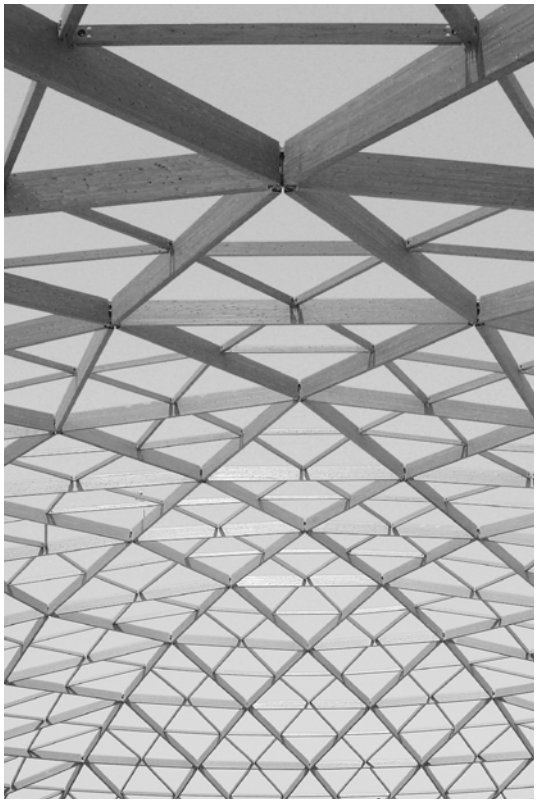

Glulam-Bulletin

December 2017

General
Load bearing components made from glued laminated timber (Glulam) are designed and carefully manufactured, top-quality construction components made from an improved and ecological material. At 8th August 2014 EN 14080: 2013, the harmonized product standard on glued laminated timber and glued solid timber has been published in the Official Journal of the EU (OJEU). The German application standard DIN 20000-3: 2015 which has to be taken into account for applications in Germany has been published in Februrary 2015 and is listed in the sample list of technical rules to be applied in Germany in November 2015.

Glulam according to DIN EN 14080: 2013 is marked with the CE-mark.

For glulam according to DIN EN 14080: 2013 no certification of suitability for gluing of load bearing timber members (so called „Leimgenehmigung“) is needed.

In the following a few generally accepted, material dependent rules shall be explained, adherence to which assures long-term stability of the structure and preservation of the appearance.

In addition a few important terms and definitions for the quality determination of Glulam will be explained.

Strength classes
Glulam is, according to DIN EN 14080, produced and divided into strength classes. The numerical value of the Glulam classes stands for the characteristic value of the bending strength in N/mm². The „h“ and/or „c“ with the designation of DIN EN 14080: 2013 stands for homogeneous and/or combined symmetrical built up Glulam. A classification to a “combination” strength class GL XX c can be achieved by the manufacturer of the glued laminated timber by means of various cross sectional layups. Glulam can be exceedingly economically manufactured with a combined layup since the higher strength boards accumulated in a grading process can then be directed to the areas of greater tensile loads and the boards of lower strength to the core or the compression loads. Due to the high costs and greater lead times required, homogeneous glued laminated timber should only be used in exceptional cases, e.g. for components stressed primarily by normal forces.

The following standard qualities are available: GL 24c, GL 28c, and GL30c. If the strength class is not specified, GL 24c is delivered.

With the ordering of GL 30c or h, in addition, one has to bear in mind that not all grading machines required for the manufacturing allow for the grading of species other than spruce/fir.

CE-mark and Declaration of Performance
According to the Building Products Directive a declaration of performance (DoP) shall be issued and the glulam shall be marked with a CE-mark. For the application in Germany at least the following characteristics shall be declared within the DoP:
- Modulus of elasticity, bending, compression, tension and shear strength
- Bonding strength
- Reaction to fire
- Release of formaldehyde
- Durability of bonding strength
- Durability of other properties

Labelling
Components made from Glulam comply with the building authorities requirements. They are labelled by the manufacturer with the CE-Mark. (see also Figure 1)

Figure 1
Example of a CE-Mark to be affixed on the product (Glulam of strength class GL 24c, spruce glued with type I adhesives and having its glue line integrity tested by delamination test method B, reaction to fire class D-s2,d0, formaldehydeemission-class E1 and durability class 5)

CE 4321	CE-Mark according to Directive No. of notified body
Manufacturer XY **15** Nr. XYZ	Name or sign of manufacturer Last to digits of the year in which the marking was affixed for the first time (usually year of type testing) No. of declaration of performance
EN 14080:2013 Glued laminated timber	Product standard and year of publication Description of product
GL 24c MUF-Typ I-B D-s2, d0 E1 DC 5	Essential characteristics being declared in the declaration of performance

Table 1:
Characteristic strength for the design of glulam according to DIN EN 1995-1-1:2010-12 and German national Annex DIN EN 1995-1-1/NA:2013-08

Strength-class [a]		**GL 24c**	**GL 28c**	**GL 30c**
Strength in N/mm²				
Bending	$f_{m,k}$ [b) c)]	24	28	30
Tension parallel to grain	$f_{t,0,k}$	17	19,5	19,5
Tension perpendicular to grain	$f_{t,90,k}$	0,5	0,5	0,5
Compression parallel to grain	$f_{c,0,k}$	21,5	24	24,5
Compression perpendicular to grain	$f_{c,90,k}$	2,5	2,5	2,5
Shear and torsional shear	$f_{v,k}$ [d)]	3,5	3,5	3,5
Stiffness in N/mm²				
Modulus of elasticity parallel to the grain	$E_{0,mean}$ [e)]	11.000	12.500	13.000
Modulus of elasticity perpendicular to the grain	$E_{90,mean}$ [e)]	300	300	300
Shear-Modulus	G_{mean} [e)]	650	650	650
Density in kg/m³				
Density	ρ_k [d)]	365	390	390

a)
Homogeneous glulam is marked with „h“ and combined glulam with „c“

b)
The characteristic bending strength of glulam with a height $h \leq 600$ mm being subjected to edgewise bending may be increased by

$$k_h = \min. \begin{cases} \left(\frac{600}{h}\right)^{0,1} \\ 1,1 \end{cases}$$

see DIN EN 1995-1-1: 2010-12, 3.3(3).

c)
The characteristic bending strength of homogenous glulam comprising at least four laminations and being subjected to flatwise bending may be increased by 20%, if DIN EN 1995-1-1:2010-12, 6.6(4) is not applied ,see DIN EN 1995-1-1/NA, NCI zu 3.3 (NA.6) and (NA.7).

d)
The characteristic value of rolling shear strength $f_{R,k}$ may be taken as 1,0 N/mm² for all glulam-strength-classes. The rolling shear-modulus may be taken as $G_{R,mean} = 0,1\ G_{mean}$.

e)
For the characteristic stiffness and density properties $E_{0,05}$, $E_{90,05}$ und G_{05} the following expressions apply
$E_{0,05} = 5/6\ E_{0,mean}$,
$E_{90,05} = 5/6\ E_{90,mean}$ and
$G_{05} = 5/6\ G_{mean}$,
see DIN EN 1995-1-1/NA, NCI Zu 3.3 (NA.8).

Cross sectional layup of members of various heights

Large volume, order related Glulam construction members manufacturing have as a rule, a combined layup. At the point of maximum bending stress M/W, the layup required for the respective strength class must be given. The reduction of the proportionate height of a boundary area with higher strength lamellae in the direction of the support is regarded as structurally unquestionable.

Reinforcements for tension perpendicular to the grain

DIN EN 1995-1-1 (Eurocode 5-1-1): 2010 permit the design of members subjected to tension stresses perpendicular to the grain either with or without reinforcements. Designs with reinforcements for tension stresses parallel to the grain according to DIN EN 1995-1-1/NA: 2013 (German National Annex to Eurocode 5-1-1) are recommended exclusively for pitched cambered beams.

Surface protection

To avoid non-beneficial moisture absorption during transportation and assembly as well as for improving the cleanability, the surfaces, with larger construction components and also the cross-grained wood, should be provided with a suitable temporary weather protection coating.

Surface qualities

Glulam components can be manufactured with various surface qualities, see Table 2, and thus fulfil variable creative requirements. The desired surface characteristics are, in each case, contractually agreed upon and are, for example, itemised in the technical specifications.
If nothing else is stipulated visible quality is assumed to be agreed.

Transport and Assembly

Transport and assembly of Glulam components should categorically only be carried out by experienced and therefore fully equipped certified specialists. Thereby, among other things, the following is to be observed:

- Sufficient bracing, also whilst under construction.
- Soiling prevention.
- During the lifting process, as a rule, the entire section should be encompassed with heavy duty binding or some other suitable device.
- Duly storage on site. Attention should be paid to the fact that coverings for transport have to be removed in order to avoid condensate and blue stain. The members should be protected by suitable coverings against moistening and contamination subsequently.
- Suitable protection of edges.
- Precise axial orientation of glulam members and temporarily bracings until the bracing is mounted.
- Final alignment of construction.
- Proctetion against corrosion should be carried out before the steel elements are mounted in order to avoid contamination of glulam surfaces by rust.
- If steel is cut or welded on site the nearby glulam surfaces should be covered in order to avoid contamination of the glulam surfaces by discolouration and rust.

Table 2
Surface qualities of Glulam

Criteria[1]	Industrial quality	Visible quality	Selection quality
Firmly grown knots [2,3]	Permitted	Permitted	Permitted
Fallen and loose knots [2, 3]	Permitted	Up to ø < 20 mm [4] permitted from ø > 20 mm to be replaced in the works [4]	To be replaced in the works
Resin gall [3, 5]	Permitted	Resin galls are permitted up to 5 mm	Resin galls are permitted up to 3 mm
Knots and faulty points improved by means of knot hole plugs or „ships“ [3]	Not necessary	Permitted	Permitted
Knots and resin galls improved by means of filler compound [3]	Not necessary	Permitted [6]	Permitted [6]
Insect attack [3]	Permitted are burrows up to 2 mm	Permitted are burrows up to 2 mm	Not permitted
Pith	Permitted	Permitted	Pith visibly on the outer lamellas is not permitted
Cracks caused by shrinking [3, 5, 7]	No limit	Up to 4 mm	Up to 3 mm
Discolorations as a result of blue stain, rote und braune nagelfeste Streifen [5]	No limit	Up to 10 % of the visible surface of the whole construction component	Not permitted
Mould [5]	Not permitted	Not permitted	Not permitted
Contamination of the surface [5]	Permitted	Not permitted	Not permitted
Distance between fingerjoints	No limit	No limit	On visible remaining outer lamellas, the distance between one another has to be at least 1 m
Surface	Levelled out	Planed and camfered chatter permitted up to a depth of 1 mm	Planed and camfered chatter permitted up to a depth o,5 mm

1 Deviations from the limit values defined in the following in lines 2, 3, 6-9, 12, 13 are to be tolerated to the following extent: maximum of three deviations/m² visible surface for the quality of vision, maximum of one deviation/m² visible surface for selection quality.
2 The maximum knot size depends on the strenth grading. In case of visual strength grading maximum allowed knot sizes may e.g. be taken from DIN 4074-1, if this grading standard is applied
3 Without limitation of the number
4 Measurement of the diameter of the knots analogue to the measurement of the diameter of individual knots for scantlings according to DIN 4074-1: 2012, 5.1.2.1.
5 Delivery condition
6 Filler compound which can be painted over is to be demanded explicitly.
7 As in all constructional solid wood products cracks can be present. The depth of the crack, measured with a 0.1 mm thick feeler gauge and independent of the quality of the surface for construction components, may be, for members not being subject to tensile-stresses perpendicular to the grain up to 1/6 of the width of the construction component, for members being subject to tensile-stresses perpendicular to the grain, up to 1/8 of the width of the component from each side. With deeper cracks the non-critical state should be checked by an expert.

A more comprehensive and illustrated description of the surface qualities can be found in the article RADOVIC/WIEGAND „Oberflächenqualität von Brettschichtholz“ [Surface quality of glued laminated timber, German language only], which is located in the download area of the website www.brettschichtholz.de

Table 3
Maximum permitted deviations

		Maximum permitted deviations Straight members	Curved members
Cross-sectional width	for all widths	± 2 mm	
Cross-sectional height	h ≤ 400 mm h > 400 mm	– 2 mm to + 4 mm – 0,5 % to + 1 %	
Maximum deviation of the angles of the cross section from the right angle		1:50	
Length of a straight member or developed length of a curved member measured along the outer edge	l ≤ 2 m 2 m < l ≤ 20 m l > 20 m	± 2 mm ± 0,1 % ± 20 mm	
Longitudinal warping measured as the maximum gauge over a length of 2 000 mm without consideration of precamber		4 mm	—
Deviations of the gauge of curved members per developed length in m	≤ 6 Laminations > 6 Laminations	— —	± 4 mm ± 2 mm

Deviation in sizes
Deviations in sizes determined by DIN EN 14080: 2013 for a reference moisture content of 12% must not exceed the values listed in Table 3. In addition to the specifications of DIN EN 14080: 2013, Table 3 also contains maximum permitted deviations for curved members. A curved member here is a member with a precamber of more than one hundredth of the span.

Limiting values for deflections
The limiting values for deflections are given in DIN EN 1995-1-1: 2010 and the respective National Annex DIN EN 1995-1-1/NA. They are only recommendations! Clients and designers have to agree upon the limiting values for deflections for each specific building. On the basis of long-term experience the Studiengemeinschaft Holzleimbau e.V. recommends the following values (values in brackets apply for cantilevered members), see Table 4.

Table 4
Recommended limiting values for deflections for beams

	w_{inst}	$w_{net,fin}$ [1)]	w_{fin}
Members other than members according to line 2	l/300 l/150 [2)]	l/300 l/150 [2)]	l/200 l/100 [2)]
Precambered members or members of minor importance such as members for agricultural buildings, rafters and purlins	l/200 l/100 [2)]	l/250 l/125 [2)]	l/150 l/75 [2)]

[1)] Deviating from DIN EN 1995-1-1: 2010 but in accordance with DIN EN 1990: 2010 and DIN EN 1995-1-1/NA: 2013 $w_{net,fin}$ is calculated as follows:

$$w_{net,fin} = \left(w_{inst,G} + \sum_{i \geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right)\left(1 + k_{def}\right) - w_c$$

[2)] for cantilevered members

Subsequent block outs, notches, openings, drilled holes and cuttings
In every case they call for a new static analysis.

Structural-physical analysis
Predominantly the outer layers of the Glulam, under construction, absorb moisture. This moisture must be gradually dispersed, until a uniform cross-sectional moisture is achived. Careful heating and ventilation and the resulting accompanying slow reduction of the relative humidity of air and the corresponding wood moisture serves this purpose.

As in all constructional timber products cracks can be present on the surfaces of the Glulam components and also along the glued joints Shrinkage cracks can appear. The depth of the crack, measured with a 0.1 mm thick feeler gauge and independent of the quality of the surface for construction components, may be, for members not being subject to tensile-stresses perpendi cular to the grain up to 1/6 of the width of the construction component, for members being subject to tensile-stresses perpendicular to the grain, up to 1/8 of the width of the component from each side. With deeper cracks the non-critical state should be checked by an expert.

With direct exposure and strong changing climatic conditions the inclination towards crack formation increases. Even during the planning, protective measures are also provided for the construction in progress. These are, in particular, coverings and backwater free drains.

Priority is given to constructional means of wood protection over preservative treatment. To this belongs, for example, prompt closure of the roof and outer wall surfaces immediately after assembly and also removal of building moisture by ventilation. For reasons of environmental and health protection, constructional means of wood protection measures should be taken that render additional use of preservative treatment unnecessary. According to DIN 68800-1: 2011, in service classes 1 and 2 (moisture content permanently < 20%), no preservative treatment against fungi or insects is required with kiln dried solid wood products such as glulam. Depending on the use class according to DIN 68800-1:2011, you can resort to durable softwood species (with no or limited sapwood) in service class 3. Pine heartwood can be used up to use class 2, larch and Douglas fir heartwood up to use class 3.1. If, in exceptional cases, preservative treatment is required, then products according to a German technical approval applicable to the respective use class shall be used.

Prior to application, however, a written opinion of the preservative agent manufacturer containing the following points should be requested:
- Necessity of surface coating and other moisture protection measures until the members are protected against weathering;
- Compatibility of preservative treatment with surface coating;
- Necessity of pre-treating the surface, in particular in the case of kiln dried spruce wood, to reach the required penetration quantity and, if applicable, penetration depth;
- Fundamental suitability of a surface application with large volume glulam timber components.

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