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European Assessment Document for

Glulam strengthened by laminated veneer lumber, glued laminated veneer lumber made of jointed laminations and block-glued glulam made thereof

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

1.1.1 General

This EAD covers glulam strengthened by laminated veneer lumber (LVL), glued laminated veneer lumber made of finger-jointed laminations GLVL-FJ) and block-glued glulam made thereof. Depending on the layup, the products are denominated as hybrid glulam, GLVL-FJ, block-glued hybrid glulam and block-glued GLVL-FJ. The products as covered by this EAD are specified in clauses 1.1.2 to 1.1.5.

The product is not fully covered by the following harmonised technical specification: EN 14080[1]. The scope of this harmonised standard is limited to glulam solely made of solid softwood or poplar laminations. This EAD covers glulam with a composite structure made of solid softwood timber laminations and LVL laminations with or without finger joints or solely made of finger-jointed LVL laminations. Hence the assessment methods given in EN 14080, which covers glulam solely made of solid softwood or poplar laminations, do not fully apply.

Since solid timber and LVL laminations are used to produce hybrid glulam and finger-jointed LVL laminations to produce GLVL-FJ, partly the essential characteristics and related assessment methods given in EN 14080 and EN 14374 are covered by this EAD, but also other new assessment methods linked with a deviating set of essential characteristics. Furthermore, as the result of the assessment of the product covered by this EAD only the strength and stiffness characteristics of hybrid glulam or GLVL-FJ made of finger-jointed LVL laminations are needed and not the properties of the laminations. Hence, the essential characteristic "Properties of timber" and "Strength of finger joints" are not included as separate essential characteristics in this EAD. Regarding bonding strength all relevant assessment methods are included in the essential characteristic "Durability of bonding strength".

GLVL-FJ and block-glued glulam made thereof in accordance with this EAD are not covered by EAD 130337-00-0304 since finger-jointed LVL laminations are not included in EAD 130337-00-0304. The finger joints in the LVL laminations may have a significant influence on the strength of GLVL-FJ and block glued glulam made thereof. Hence, provisions regarding the assessment of the finger-jointed LVL laminations are included in this EAD, see clauses 2.2.1.4, 2.2.1.5.2, 2.2.1.5.4 and 2.2.15. The EAD covers

– Hybrid glulam comprising homogeneous or combined glulam in accordance with EN 14080with maximum cross-sectional sizes in accordance with EN 14080 strengthened by LVL laminations with or without finger joints with maximum cross-sectional sizes as used in the modified shear test in accordance with clause 2.2.18.4 in connection with clause 2.2.18.1 and that fulfils the requirement given in EN 14374, clause 4.2,
– hybrid glulam and block-glued hybrid glulam type ii) with a mean relative shear strength rel $f_{v,block} \geq 0{,}70$ (ratio of shear strength after boiling treatment to shear strength at dry conditions) in accordance with clause 2.2.18.4 respective 2.2.18.6.

The EAD covers hybrid glulam, GLVL-FJ made of finger-jointed LVL laminations, block-glued hybrid glulam and block-glued GLVL-FJ made of finger-jointed LVL laminations

– which are manufactured considering the special instructions for the respective softwood or hardwood species of the adhesive manufacturer regarding additional provisions for the surface treatment before gluing, reduced times between surface treatment and gluing, pre-treatment with a primer, open and closed assembly times as well as pressing times;
– with a geometry of the fingers that permits the joint to be self-interlocking after pressing;
– with a geometry of the finger joints of the laminations in accordance with EN 14080, Annex I.4.2;
– with finished lamination sizes and radius of curvature in accordance with EN 14080, Annex I.5.1;
– with a maximum deviation from the average lamination thickness in accordance with Annex I.5.6 of EN 14080,
– with a factor $k_{j,LVL}$ in accordance with equation (2.2.1.4.1) of $k_{j,LVL} \geq 0{,}7$ (see clause 2.2.1.4).

[1] All undated references to standards in this EAD are to be understood as references to the dated versions listed in clause 4.

The EAD does not cover glulam that is

- wood preservative treated against biological attack;
- made of wood treated with flame retardants;
- made of recycled wood.

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations, e.g., with regard to the intended end use conditions, having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA as long as the details of the assessment methods as laid down in this EAD are respected.

1.1.2 Hybrid glulam

Hybrid glued laminated timber (in the following referred to as hybrid glulam) is made of homogeneous or combined glulam in accordance with EN 14080 strengthened by LVL laminations with or without finger joints arranged in the tensile or in the tensile and compression zone of the product, see also Figure 1.1.2.1.

The glulam is made of solid softwood laminations strength graded in accordance with EN 14081-1. The glulam is used as inner part of the hybrid glulam. The solid softwood laminations of the glulam are assigned to a tension strength class (T-class) in accordance with EN 338 or into an individual tension strength profile defined by the characteristic tensile strength $f_{t,0,l,k}$, the modulus of elasticity $E_{0,l,mean}$ and the characteristic density $\rho_{l,k}$. The solid softwood laminations may contain finger joints fulfilling the provisions of EN 14080, clause 5.1.4.2.The outer laminations of the hybrid glulam are made of LVL in accordance with EN 14374 without crossband veneers made of softwoods or birch or beech. They may contain finger joints.

The EAD covers hybrid glulam with solid softwood laminations with finger joints in accordance with EN 14080, Annex I.4.1 and I.4.3.

Hybrid glulam can consist of laminations made of two boards side by side in accordance with Annex I.5.2 of EN 14080. It also can have grooves in laminations in accordance with Annex I.5.3 of EN 14080.

Adhesives of type I in accordance with EN 301 or EN 15425 with the letter "w" in the designation are used to produce hybrid glulam.

Regarding geometry and beam-lay-up hybrid glulam complies with EN 14080, clauses 3.15 and 5.11.1, and Figure 1.1.2.1.

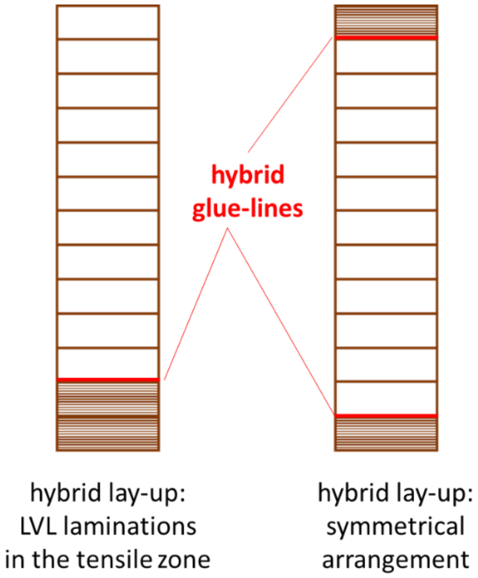


Figure 1.1.2.1: Examples for hybrid glulam lay-up - asymmetrical and symmetrical hybrid glulam

1.1.3 GLVL-FJ made of LVL with finger joints

This EAD also covers glulam solely made of LVL laminations with finger joints (in the following referred to as GLVL-FJ), see also Figure 1.1.3.1.

The laminations are made of LVL in accordance with EN 14374 without crossband veneers made of softwood or birch or beech. They contain finger joints in accordance with EN 14080, Annex I.4, whereby Annex I.4.3 and I.4.4 do not apply.

Adhesives of type I in accordance with EN 301 or EN 15425 with the letter "w" in the designation are used to produce GLVL-FJ.

Regarding geometry and beam-lay-up GLVL-FJ complies with EN 14080, clauses 3.15 and 5.11.1, and Figure 1.1.3.1.

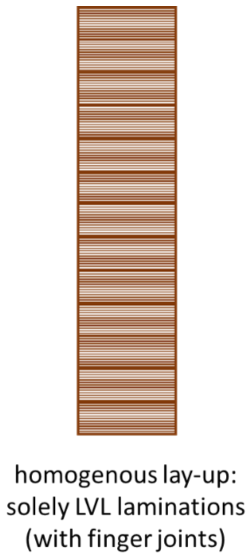


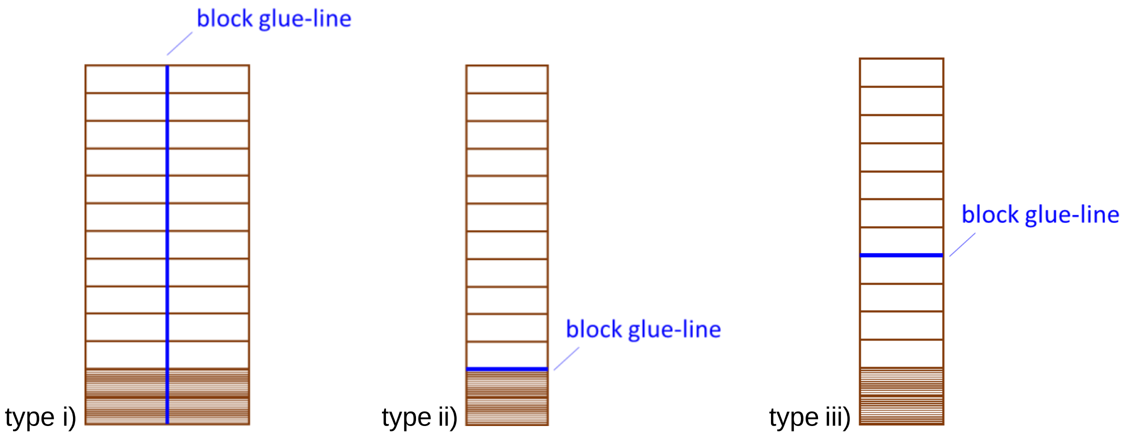
Figure 1.1.3.1: Lay-up of GLVL-FJ made from LVL laminations with finger-joints

1.1.4 Block-glued hybrid glulam

Block-glued hybrid glulam in accordance with Figure 1.1.4.1 is also covered by this EAD.

For block gluing of block-glued glulam type i) adhesives of type EN 301 I 90 GF 1,5M w are used. For block gluing of block-glued glulam types ii) and iii) adhesives of type EN 301 I 90 GF 1,5M w or EN 301 I 90 GP 0,6M w are used.

Regarding geometry and beam-lay-up block-glued hybrid glulam complies with EN 14080, clauses 3.3 and 5.11.1, and Figure 1.1.4.1.



type i) Block glue-line at the narrow faces of the laminations – identic beam-lay-up

type ii) Block glue-line at the faces between finger-jointed LVL laminations and solid wood laminations

type iii) Block glue-line at the faces of the solid wood laminations

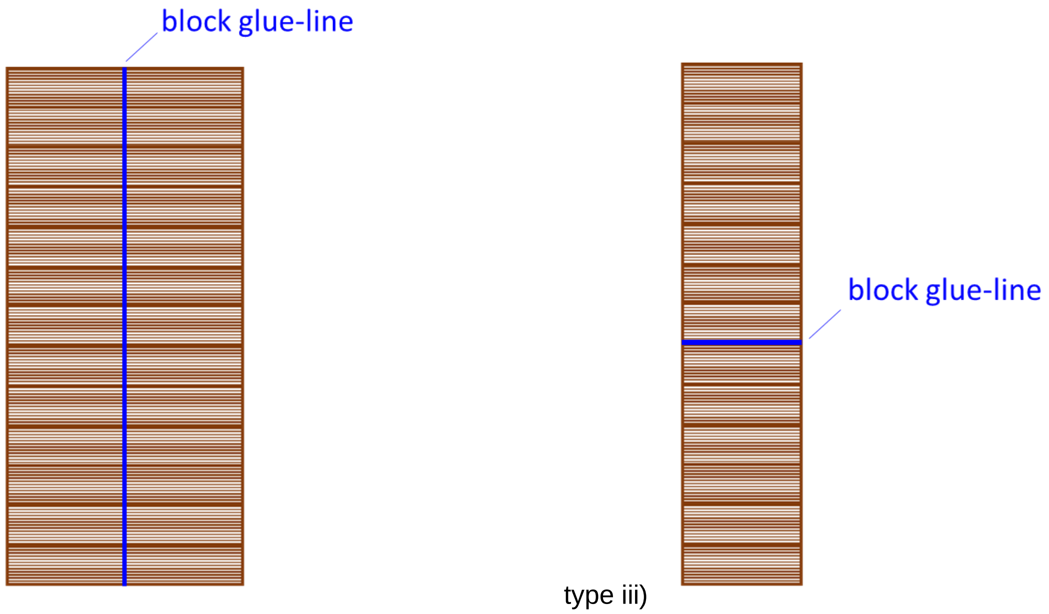
Figure 1.1.4.1: Types of block-glued hybrid glulam

1.1.5 Block-glued GLVL-FJ

This EAD also covers block-glued GLVL-FJ made of LVL with finger joints in accordance with Figure 1.1.5.1 comprising up to 3 GLVL-FJ components for type i) and 2 GLVL-FJ components for type iii). The same provisions as for block-glued hybrid glulam apply.

For block gluing of block-glued GLVL-FJ types i) and iii) adhesives of type EN 301 I 90 GF 1,5M w are used.

Regarding geometry and beam-lay-up block-glued GLVL-FJ complies with EN 14080, clauses 3.3 and 5.11.1 and Figure 1.1.5.1.



type i) type iii)

Figure 1.1.5.1: Types of block-glued GLVL-FJ

1.2 Information on the intended use of the construction product

1.2.1 Intended use

Glulam strengthened by LVL, GLVL-FJ made of LVL with finger joints and block-glued glulam made thereof are intended to be used in load-bearing timber structures in service classes 1 to 2 in accordance with EN 1995-1-1, clause 2.3.1.3.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the glulam strengthened by LVL, GLVL-FJ and block-glued glulam made thereof for the intended use of 50 years when installed in the works provided that the glulam strengthened by LVL, GLVL-FJ and block-glued glulam made thereof is subject to appropriate installation (see 1.1). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[2].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD (if necessary, in addition to the definitions in CPR, Art 2)

1.3.1 Hybrid glue-line

Hybrid glue-line is defined as a glue-line between a solid timber and a LVL lamination.

1.3.2 Strengthening level

Strengthening level is defined as the cross-section percentage of LVL laminations of the total cross-section of the hybrid glulam.

1.3.3 Main symbols

B width

COV coefficient of variation of the test results

E modulus of elasticity (MOE)

f strength

G shear modulus

H depth

I second moment of area

k factor

L length

M Moment

min minimum

rel f relative strength

ρ density, in kg/m³

s size effect parameter

σ stress

y_{top} distance from the centroid of the cross section of the hybrid glulam to the upper cross section edge

2 The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

y_{bot} distance from the centroid of the cross section of the hybrid glulam to the lower cross section edge

W section modulus

W_{ideal} idealized section modulus

1.3.4 Subscripts

block block-glued

c compression

edge edgewise

test assessed by tests

flat flatwise

g properties of the glued laminated timber (solid timber)

GLVL-FJ glulam solely made of finger-jointed LVL laminations

h height of cross-section

j properties of finger joints in laminations

k characteristic

l properties of laminations

large heights larger than 600 mm

LVL properties of LVL laminations

m bending

max maximum

mean mean valuer rolling shear

ref reference properties

small heights smaller than 600 mm

t tensile

tot properties of the whole cross section

v shear

0 parallel to the grain

05 5 %-fractile

1 part 1 of a cross section

2 part 2 of a cross section

90 perpendicular to the grain

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of glulam strengthened by LVL, GLVL-FJ and block-glued glulam made thereof is assessed in relation to the essential characteristics.

Table 2.1.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Bending strength – Flatwise bending of the laminations	2.2.1	Level $f_{m,flat,k}$ [N/mm²]
2	Bending strength – Edgewise bending of the laminations	2.2.2	Level $f_{m,edge,k}$ [N/mm²]
3	Tensile strength parallel to the grain	2.2.3	Level $f_{t,0,k}$ [N/mm²]
4	Tensile strength perpendicular to the grain	2.2.4	Level $f_{t,90,flat,k}$ [N/mm²] $f_{t,90,edge,k}$ [N/mm²]
5	Compression strength parallel to the grain	2.2.5	Level $f_{c,0,k}$ [N/mm²]
6	Compression strength perpendicular to the grain	2.2.6	Level $f_{c,90,flat,k}$ [N/mm²] $f_{c,90,edge,k}$ [N/mm²]
7	Shear strength	2.2.7	Level $f_{v,k}$ [N/mm²] or $f_{v,flat,k}$ [N/mm²] and $f_{v,edge,k}$ [N/mm²]
8	Rolling shear strength	2.2.8	Level $f_{r,k}$ [N/mm²]
9	Modulus of elasticity parallel to the grain	2.2.9	Level $E_{0,mean}$ [N/mm²] $E_{0,05}$ [N/mm²]
10	Modulus of elasticity perpendicular to the grain	2.2.10	Level $E_{90,flat,mean}$ [N/mm²] $E_{90,flat,05}$ [N/mm²] $E_{90,edge,mean}$ [N/mm²] $E_{90,edge,05}$ [N/mm²]

No	Essential characteristic	Assessment method	Type of expression of product performance
11	Shear modulus	2.2.11	Level G_{mean} [N/mm²] or $G_{flat,mean}$ [N/mm²] and $G_{edge,mean}$ [N/mm²] G_{05} [N/mm²] or $G_{flat,05}$ [N/mm²] and $G_{edge,05}$ [N/mm²]
12	Rolling shear modulus	2.2.12	Level $G_{r,mean}$ [N/mm²] $G_{r,05}$ [N/mm²]
13	Density	2.2.13	Level ρ_{mean} in kg/m³ ρ_k in kg/m³
14	Dimensional stability	2.2.14	Description
Basic Works Requirement 2: Safety in case of fire			
15	Reaction to fire	2.2.15	Class
16	Resistance to fire	2.2.16	Level
Basic Works Requirement 3: Hygiene, health and the environment			
17	Content, emission and/or release of dangerous substances	2.2.17	Class
Aspects of durability			
18	Durability of bonding strength	2.2.18	Description
19	Durability against biological attack	2.2.19	Class

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

If for any components covered by harmonised standards or European Technical Assessments the manufacturer of the component has included the performance regarding the relevant essential characteristic in the Declaration of Performance, retesting of that component for issuing the ETA under the current EAD is not required.

The performance for the essential characteristics of block-glued hybrid glulam (see Figure 1.1.4.1) shall be assessed as given for hybrid glulam (see Figure 1.1.2.1), if there are no separate provisions given in the following sections. The performance for the essential characteristics of block-glued GLVL-FJ (see Figure 1.1.5.1) shall be assessed as for GLVL-FJ (see Figure 1.1.3.1), if there are no separate provisions given in the following sections.

2.2.1 Bending strength – Flatwise bending of the laminations

2.2.1.1 General

In clauses 2.2.1.2 to 2.2.1.4 the assessment of properties of the components of hybrid glulam and GLVL-FJ are given. The assessment of the bending strength of hybrid glulam and GLVL-FJ with flatwise bending of the laminations is given in clause 2.2.1.5.

2.2.1.2 Properties of solid timber glulam

Based on the properties of the solid timber laminations the strength class or strength profile of the solid timber glulam part of the cross-section shall be assessed using Table 5 or Table 6 in EN 14080 for homogeneous lay-ups of the solid timber glulam, i.e., the properties of solid timber glulam shall be taken as the properties of the assessed strength class in accordance with Table 5 or shall be calculated in accordance with Table 6 in EN 14080.

In case of an inhomogeneous lay-up within the solid glulam part – i.e., in case of a combination of laminations of different strength classes – the effective properties of the inhomogeneous solid glulam shall be determined by means of elastic composite beam theory in accordance with EN 14080, clause 5.1.5.3 (reference method), or from Table 4 in EN 14080 as simplified method.

2.2.1.3 Properties of LVL laminations without finger joints

In case of LVL laminations without finger joints the characteristic tensile strength parallel to the grain $f_{t,0,l,LVL,k}$ shall be determined in accordance with EN 14374, clause 4.4.4. The characteristic compression strength parallel to the grain $f_{c,0,l,LVL,k}$ shall be determined as given in EN 14374, clause 4.4.6. The characteristic flatwise bending strength $f_{m,flat,l,LVL,k}$ shall be determined as given in EN 14374, clause 4.4.3. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

The mean modulus of elasticity in tension parallel to the grain of the face veneers $E_{t,0,l,LVL,mean}$ shall be taken as the modulus of elasticity in edgewise bending $E_{m,0,edge,l,LVL,mean}$, that is determined in accordance with EN 14374, clause 4.5.2.

If there is a declaration of performance of the LVL in accordance with EN 14374 the values of $f_{t,0,l,LVL,k}$, $f_{t,90,flat,LVL,k}$, $f_{c,0,l,LVL,k}$, $f_{m,flat,l,LVL,k}$, and $E_{t,0,l,LVL,mean}$ shall be taken from the declaration of performance, if declared.

2.2.1.4 Strength of LVL laminations with finger joints

In case of finger-jointed LVL laminations a strength reduction factor $k_{j,LVL}$ shall be determined as follows:

The tensile strength parallel to the grain $f_{t,0,j,LVL,k,test}$ of the LVL laminations with finger joints and of the LVL laminations without finger joints $f_{t,0,l,LVL,k,test}$ shall be determined in accordance with the provision in Table 2.2.1.4.1, lines 1 and 2. The characteristic values shall be calculated in accordance with EN 14358 using a logarithmical normal distribution. The strength reduction factor $k_{j,LVL}$ shall be determined in accordance with equation (2.2.1.4.1).

$$k_{j,LVL} = \min \left(f_{t,0,j,LVL,k,test} / f_{t,0,l,LVL,k,test}; 1 \right) \quad (2.2.1.4.1)$$

Table 2.2.1.4.1 Specification of the determination of finger-jointed lamination strength

Tests of the laminations[3]	Test method	Specimen type	Minimum Number
Tensile strength parallel to the grain of finger joints in LVL $f_{t,0,j,kLVL,k,test}$	EN 14080, Annex E	Typical cross-section*	30 per LVL product, finger joint adhesive and finger joint press
Tensile strength parallel to the grain of LVL laminations $f_{t,0,l,kLVL,k,test}$			30 per LVL product, finger joint adhesive and finger joint press
* Typical cross-section: approximately 2/3 of the largest cross-sectional width and at least 2/3 of the largest cross-sectional depth of the LVL laminations			

2.2.1.5 Bending strength of hybrid glulam and GLVL-FJ

2.2.1.5.1 General

In the following methods to assess the characteristic bending strength of hybrid glulam or GLVL-FJ - Flatwise bending of the laminations - $f_{m,flat,k}$ are given, full scale testing (clause 2.2.1.5.2) as reference method and alternatively, one simplified method for hybrid glulam and GLVL-FJ (clause 2.2.1.5.3) and one simplified method only valid for hybrid glulam (clause 2.2.1.5.4). One of the three assessment methods given in clauses 2.2.1.5.2 to 2.2.1.5.4 can be used where the full-scale tests are the reference method and the elastic composite beam theory and the numerical model are simplified, alternative methods.

The characteristic flatwise bending strength of hybrid glulam or GLVL-FJ $f_{m,flat,k}$ shall be given in the ETA together with the information about the assessment method used.

2.2.1.5.2 Bending strength of hybrid glulam and GLVL-FJ - Flatwise bending of the laminations, determined from full scale tests as reference method

As reference method the characteristic bending strength of hybrid glulam or GLVL-FJ - Flatwise bending of the laminations - $f_{m,flat,k}$ shall be determined from full scale tests in accordance with Table 2.2.1.5.2.1.

3 For all tests: The density and the moisture content of all specimens shall be determined and reported.

The specimens shall be tested in bending in accordance with EN 408 whereby the location of finger joints (in case of finger-jointed LVL laminations) is given in Figure 2.2.1.5.2.1. The finger joints shall be randomly distributed as in usual industrial production and shall conform with the following provision:

Every tested specimen should exhibit at least one finger joint in the outer lamination at the tension edge of the cross-section within the zone of constant bending moment.

Table 2.2.1.5.2.1 Specification of the determination of the flatwise bending strength of the hybrid glulam or GLVL-FJ - Flatwise bending of the laminations

Tests of the hybrid glulam 3 and GLVL-FJ3	Test method	Specimen type	Minimum Number
Bending strength fm,flat,k	EN 14080, Annex F	Smallest cross-sectional height	15 per LVL product, strengthening level, glulam strength class, finger joint adhesive and finger joint press
		Intermediate cross-sectional height*	10 per LVL product, strengthening level, glulam strength class, finger joint adhesive and finger joint press
		H = 600 mm or largest cross-sectional height (whatever is smaller)	10 per LVL product, strengthening level, glulam strength class, finger joint adhesive and finger joint press
* Intermediate cross-sectional height, i.e., approximately 50 % of the largest cross-sectional height			

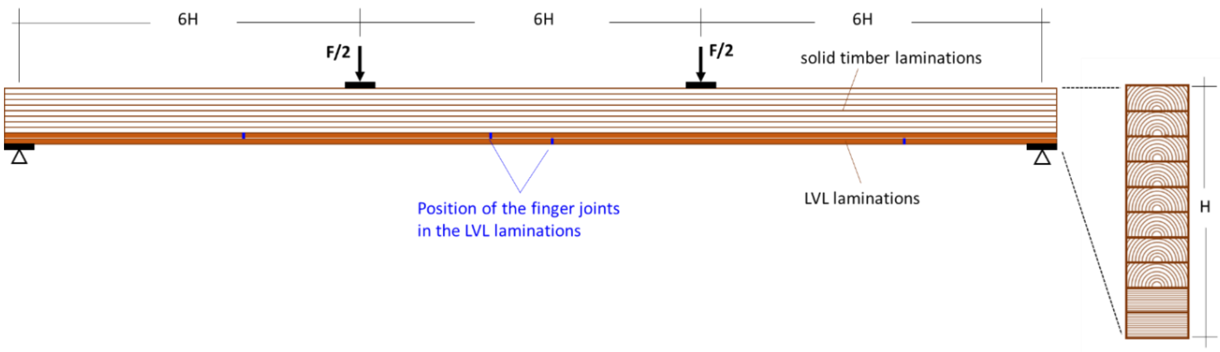


Figure 2.2.1.5.2.1: Exemplary test setup for the determination of the bending strength of hybrid glulam – Flatwise bending of the laminations

2.2.1.5.3 Bending strength of symmetrical hybrid glulam and GLVL-FJ - Flatwise bending of the laminations, determined from properties of LVL laminations, finger joints in LVL laminations and of solid glulam – Elastic composite beam theory

As simplified method the bending strength of symmetrical hybrid glulam or GLVL-FJ - Flatwise bending of the laminations - fm,flat,k shall be determined using the principles of the elastic composite beam theory in accordance with Annex C from:

- bending strength $f_{m,g,k}$ of solid timber glulam (for symmetrical hybrid glulam only, see clause 2.2.1.2);
- flatwise bending strength $f_{m,flat,l,LVL,k}$ of LVL laminations (see clause 2.2.1.3);
- tensile strength $f_{t,0,l,LVL,k}$ of LVL laminations (see clause 2.2.1.3);
- MOE $E_{0,g,mean}$ of solid timber glulam (for symmetrical hybrid glulam only) (see clause 2.2.1.2);
- MOE $E_{t,0,l,LVL,mean}$ of LVL laminations (see clause 2.2.1.3).

If finger-jointed LVL laminations are used to manufacture symmetrical hybrid glulam or GLVL-FJ the tensile strength ft,0,l,LVL,k and the flatwise bending strength of the LVL laminations fm,flat,l,LVL,k shall be modified by multiplication with the reduction factor kj,LVL in accordance with equation (2.2.1.4.1).

2.2.1.5.4 Bending strength of hybrid glulam - Flatwise bending of the laminations, determined from properties of laminations and finger joints – Numerical Model

A further simplified method to determine the bending strength of hybrid glulam - flatwise bending of the lamination - fm,flat,k is described in the following. The method can be used for:

- Hybrid glulam strengthened only on one side,
- having a strengthening level ≤ 20 %.

The characteristic bending strength of the hybrid glulam - flatwise bending of the laminations - fm,,flat,k shall be determined from the strength and stiffness properties of the LVL laminations (see clauses 2.2.1.3 and 2.2.1.4) and of the solid glulam (see clause 2.2.1.2) by means of a nonlinear Finite Element-based model specified in Annex B.

When hybrid glulam with finger-jointed LVL laminations shall be assessed the tensile strength parallel to the grain ft,0,l,LVL,k (see clause 2.2.1.3) shall be reduced by the factor kj,LVL in accordance with equation (2.2.1.4.1).

The basic principles of the method are given in Annex B. The concept and corner stones of the calculation scheme shall be recorded.

The strength values of beams with heights H smaller than 600 mm may be adjusted by the factor kh,small in accordance with equation (2.2.1.5.4.1)[4],

$$k_{h,small} = \min \begin{cases} \left(\frac{600}{H}\right)^{0,1} \\ 1.1 \end{cases} \qquad (2.2.1.5.4.1)$$

The strength values of beams with heights H larger than 600 mm shall be adjusted by the factor kh,large in accordance with equation (2.2.1.5.4.2)

4 That means that the increase of the bending strength for smaller cross sections by the factor $k_{h,small}$ is optionally.

$$k_{h,large} = \left(\frac{600}{H}\right)^{0,1} \qquad (2.2.1.5.4.2)$$

The tests in accordance with Table 2.2.1.5.4.1, lines 1 and 2, shall be carried out to verify the approach based on the nonlinear Finite Element-based model specified in Annex B. At least two strengthening levels shall be tested, in the following referred to as strengthening levels 1 and 2. In case of finger-jointed laminations also tests in accordance with Table 2.2.1.5.4.1, lines 3 and 4, shall be performed. The specimens shall be tested in bending in accordance with EN 408 whereby the location of finger joints is given in Figure 2.2.1.5.4.1. The finger joints shall be randomly distributed as in usual industrial production and shall conform with the following provisions:

- Every tested specimen shall exhibit at least one finger joint in the outer lamination at the tension edge of the cross-section within the zone of constant bending moment.
- Strengthening levels 1 and 2 shall differ by a factor of at least 2.

Table 2.2.1.5.4.1 Specification of the determination of the bending strength of the hybrid glulam – Flatwise bending of the laminations

Tests of the hybrid glulam[3]	**Test method**	**Specimen type**	**Minimum Number**
Bending strength $f_{m,flat,k}$	EN 14080, Annex F	Strengthening level 1, LVL laminations without finger joints	7 per LVL wood species or product respective species grouping
		Strengthening level 2, LVL laminations without finger joints	7 per LVL wood species or product respective species grouping
	EN 14080, Annex F	Strengthening level 1, LVL laminations with finger joints	7 per LVL wood species or product respective species grouping
		Strengthening level 2, LVL laminations with finger joints	7 per LVL wood species or product respective species grouping

The characteristic bending strength of hybrid glulam $f_{m,flat,k}$, assessed by using the numerical model, shall be used if the value is equal or lower than the characteristic value assessed by testing as specified above. In the case that the characteristic bending strength of hybrid glulam, assessed by using the numerical model, is higher than the characteristic value assessed by testing the tested value shall be taken. In the latter case the application of the results is bound to the tested cross-sectional lay-ups.

2.2.2 Bending strength – Edgewise bending of the laminations

2.2.2.1 General

In the following, methods to assess the characteristic bending strength of hybrid glulam or GLVL-FJ - edgewise bending of the laminations - fm,edge,k are given, i.e., full-scale testing (clause 2.2.2.2) as reference method and, alternatively, simplified methods (clauses 2.2.2.3 and 2.2.2.4). Clause 2.2.2.3 gives the assessment method for hybrid glulam. Clause 2.2.2.4 gives the assessment method for GLVL-FJ. One of the assessment methods given in clauses 2.2.2.2 and 2.2.2.3/2.2.2.4 shall be used where the full-scale tests are the reference method and the simplified methods are the alternative methods.

The characteristic edgewise bending strength of hybrid glulam or GLVL-FJ fm,edge,k shall be given in the ETA together with the information about the assessment method used.

The bending strength capacity of block-glued hybrid glulam with edgewise orientation of the laminations shall be given as the bending strength fm,edge,k and the tensile strength parallel to grain ft,0,k of the hybrid glulam, where ft,0,k is determined as set out in clause 2.2.3.

The bending strength capacity of block-glued GLVL-FJ with edgewise orientation of the laminations shall be given as the bending strength fm,edge,k and the tensile strength parallel to grain ft,0,k of the GLVL-FJ, where ft,0,k is determined as set out in clause 2.2.3.

2.2.2.2 Bending strength of hybrid glulam and GLVL-FJ - Edgewise bending of the laminations, determined from full-scale tests as reference method

As reference method the characteristic bending strength of hybrid glulam - Flatwise bending of the laminations - fm,edge,k shall be determined from full-scale tests in accordance with Table 2.2.2.2.1.

The specimens shall be tested in bending in accordance with EN 408 whereby the location of finger joints (in case of finger-jointed LVL laminations) is given in Figure 2.2.1.5.2.1. The finger joints shall be randomly distributed as in usual industrial production. Deviating from Figure 2.2.1.5.2.1 the specimen shall be tested with edgewise orientation of the laminations.

Table 2.2.2.2.1 Specification of the determination of the bending strength of the hybrid glulam and GLVL-FJ - Edgewise bending of the laminations

Tests of the hybrid glulam and GLVL-FJ	Test method	Specimen type	Minimum Number
Bending strength $f_{m,fedge,k}$	EN 14080, Annex F	Smallest cross-sectional height	15 per LVL product, strengthening level, glulam strength class, finger joint adhesive and finger joint press

2.2.2.3 Bending strength of hybrid glulam - Edgewise bending of the laminations, determined from properties of LVL laminations, finger joints in LVL laminations and of solid glulam – Elastic composite beam theory

As simplified method the characteristic bending strength of hybrid glulam - edgewise bending of laminations - fm,edge,k shall be determined by using the principles of the elastic composite beam theory in accordance with Annex C.3 from

– bending strength $f_{m,g,k}$ and the modulus of elasticity parallel to the grain $E_{0,g,mean}$ of solid timber glulam (see clause 2.2.1.1),

– edgewise bending strength $f_{m,0,edge,l,LVL,k}$ and the modulus of elasticity parallel to the grain $E_{0,l,LVL,mean}$ of LVL laminations.

The edgewise bending strength of LVL laminations $f_{m,0,edge,l,LVL,k}$ shall be determined as set out in EN 14374, clause 4.4.2, and the modulus of elasticity parallel to the grain $E_{0,l,LVL,mean}$ as given in EN 14374, clause 4.5.2.

In case of finger-jointed LVL laminations the edgewise bending strength of LVL laminations $f_{m,edge,l,LVL,k}$ shall be multiplied with the reduction factor $k_{j,LVL}$ as defined in equation (2.2.1.4.1).

2.2.2.4 Bending strength of GLVL-FJ - Edgewise bending of the laminations

The characteristic bending strength of GLVL-FJ - edgewise bending of laminations - is the bending strength of LVL $f_{m,0,edge,l,LVL,k}$ multiplied by the reduction factor $k_{j,LVL}$ in accordance with equation (2.2.1.4.1). The edgewise bending strength of LVL laminations $f_{m,0,edge,l,LVL,k}$ shall be determined as set out in EN 14374, clause 4.4.2.

2.2.3 Tensile strength parallel to the grain

2.2.3.1 General

In the following methods to assess the characteristic tensile strength parallel to grain of hybrid glulam and GLVL-FJ $f_{t,0,k}$ are given, i.e., full-scale testing (clause 2.2.3.2) as reference method for hybrid glulam and GLVL-FJ and, alternatively, one simplified method for hybrid glulam (clause 2.2.3.3) and one simplified assessment method for GLVL-FJ. One of the assessment methods given in clauses 2.2.3.2 and 2.2.3.3/ 2.2.3.4 can be used where the full-scale tests are the reference method.

The characteristic tensile strength of hybrid glulam or GLVL-FJ $f_{t,0,k}$ shall be given in the ETA together with the information about the assessment method used.

2.2.3.2 Tensile strength parallel to grain of hybrid glulam and GLVL-FJ, determined from full-scale tests as reference method

As reference method the characteristic tensile strength parallel to grain of hybrid glulam and GLVL-FJ ft,0,k shall be determined from full-scale tests in accordance with Table 2.2.3.2.1.

The specimens shall be tested in tension in accordance with EN 408, clause 13. The finger joints (in case of finger-jointed LVL laminations) shall randomly be distributed as in usual industrial production. The characteristic value of the tensile strength parallel to grain shall be calculated from the individual tensile strength values in accordance with EN 14358 using a logarithmical normal distribution.Table 2.2.3.2.1 Specification of the determination of the tensile strength parallel to grain of the hybrid glulam and GLVL-FJ

Tests of the hybrid glulam and GLVL-FJ	**Test method**	**Specimen type**	**Minimum Number**
Tensile strength parallel to grain $f_{t,0,k}$	EN 408, clause 13	Smallest cross-sectional height	15 per LVL product, strengthening level, glulam strength class, finger joint adhesive and finger joint press

2.2.3.3 Tensile strength parallel to grain of hybrid glulam – Elastic composite beam theory

As simplified method the characteristic tensile strength parallel to the grain ft,0,k of hybrid glulam shall be determined using the principles of the elastic composite beam theory in accordance with Annex C.4 from

– the tensile strength $f_{t,0,g,k}$ and the modulus of elasticity parallel to the grain $E_{0,g,mean}$ of solid timber glulam (see clause 2.2.1.1) and
– the tensile strength $f_{t,0,l,LVL,k}$ and the modulus of elasticity parallel to the grain $E_{0,,lLVL,mean}$ of the LVL laminations (see clause 2.2.1.2).

In case of finger-jointed LVL laminations the tensile strength of LVL ft,0,l,LVL,k shall be multiplied by the reduction factor kj,LVL in accordance with equation (2.2.1.4.1).

2.2.3.4 Tensile strength parallel to grain of GLVL-FJ

As simplified method the characteristic tensile strength of GLVL-FJ is the tensile strength of LVL ft,0,LVL,k multiplied by the reduction factor kj,LVL in accordance with equation (2.2.1.4.1).

2.2.4 Tensile strength perpendicular to the grain

2.2.4.1 Tension perpendicular to the glue-lines between the laminations

The characteristic tensile strength perpendicular to the grain $f_{t,90,flat,k}$ of hybrid glulam and GLVL-FJ shall be taken from equation (2.2.4.1.1).

$f_{t,90,flat,k}$ = min (0,5 N/mm^2; $f_{t,90,flat,LVL,k}$) (2.2.4.1.1)

where

ft,90,flat,LVL,k is the characteristic tensile strength perpendicular to the grain of the LVL laminations with flatwise orientation of the LVL laminations. If ft,90,flat,LVL,k is unknown it shall be taken as 0,15 N/mm2.

The tensile strength perpendicular to the grain with flatwise orientation of the laminations ft,90,flat,LVL,k shall be determined as given in clause 16 of EN 408. The specimen size given in EN 408, clause 16.1.2.3, shall be used. The minimum number of specimens is 15. The characteristic values shall be calculated as set out in EN 14358 using a logarithmical normal distribution. The characteristic value of the tensile strength perpendicular to the grain with flatwise orientation of the laminations ft,90,flat,LVL,k shall be multiplied with a size effect factor:

ksize,t,90,flat = min ((600/H)s;1) (2.2.4.1.2).

where

H is the depth of the hybrid glulam or GLVL-FJ

s size effect parameter

$s = 2 \cdot COV - 0{,}05$ (2.2.4.1.3)

where

COV is the coefficient of variation of the test results, which shall be larger than or equal to 0,10.

If the size effect parameter s is unknown it shall be taken as s = 0,15.

The characteristic tensile strength perpendicular to the grain with flatwise orientation of the LVL laminations $f_{t,90,flat,k}$ shall be given in the ETA.

2.2.4.2 Tension parallel to the glue-lines between the laminations

2.2.4.2.1 General

In the following methods to assess the characteristic tensile strength perpendicular to grain - parallel to the glue-lines between the laminations - of hybrid glulam and GLVL-FJ $f_{t,90,edge,k}$ are given.

Clause 2.2.4.2.2 gives the assessment method for hybrid glulam. Clause 2.2.4.2.3 gives the assessment method for GLVL-FJ.

The characteristic tensile strength of hybrid glulam or GLVL-FJ $f_{t,90,edge,k}$ shall be given in the ETA.

2.2.4.2.2 Tensile strength perpendicular to grain - parallel to the glue-lines between the laminations - of hybrid glulam – Elastic composite beam theory

the characteristic tensile strength perpendicular to the grain $f_{t,90,edge,k}$ of hybrid glulam shall be determined by using the principles of the elastic composite beam theory in accordance with Annex C.5 from

- the characteristic tension strength perpendicular to the grain of the solid timber glulam $f_{t,90,g,k}$ = 0,5 N/mm^2 and the mean modulus of elasticity perpendicular to grain of solid timber glulam $E_{90,g,mean}$ (see clause 2.2.1.1) and
- the characteristic tensile strength perpendicular to the grain of the LVL laminations with edgewise orientation of the LVL laminations $f_{t,90,edge,l,LVL,k}$ and the mean modulus of elasticity perpendicular to grain $E_{90,LVL,mean}$ of the LVL laminations.

The tensile strength perpendicular to the grain with edgewise orientation of the laminations $f_{t,90,edge,l,LVL,k}$ shall be assessed as set out in EN 14374, clause 4.4.5. The mean modulus of elasticity perpendicular to grain $E_{90,l,LVL,mean}$ of the LVL laminations shall be determined as given in EN 14374, clause 4.5.3.

2.2.4.2.3 Tensile strength perpendicular to grain - parallel to the glue-lines between the laminations of GLVL-FJ

The characteristic tensile strength perpendicular to grain - parallel to the glue-lines between the laminations of GLVL-FJ is the edgewise tensile strength perpendicular to the grain of LVL ft,90,edge,l,LVL,k multiplied by the reduction factor kj,LVL in accordance with equation (2.2.1.4.1). The tensile strength perpendicular to the grain with edgewise orientation of the laminations ft,90,edge,l,LVL,k shall be assessed as set out in EN 14374, clause 4.4.5

2.2.5 Compression strength parallel to the grain

2.2.5.1 General

In the following methods to assess the characteristic compression strength parallel to grain of hybrid glulam and GLVL-FJ fc,0,k are given, i.e., full-scale testing (clause 2.2.5.2) as reference method and, alternatively, a simplified method for hybrid glulam (clause 2.2.5.3) and one for GLVL-FJ (clause 2.2.5.4). One of the two assessment methods given in clauses 2.2.5.2 and 2.2.5.3/2.2.5.4 can be used where the full-scale tests are the reference method.

The characteristic compression strength of hybrid glulam or GLVL-FJ fc,0,k shall be given in the ETA together with the information about the assessment method used.

2.2.5.2 Compression strength parallel to grain of hybrid glulam and GLVL-FJ determined from full-scale tests as reference method

As reference method the characteristic tensile strength parallel to grain of hybrid glulam and GLVL-FJ ft,0,k shall be determined from full scale tests in accordance with Table 2.2.5.2.1.

The specimens shall be tested in compression in accordance with EN 408, clause 15. The finger joints in LVL laminations shall be randomly distributed as in usual industrial production. The characteristic value of the compression strength parallel to grain shall be calculated from the individual compression strength values in accordance with EN 14358 using a logarithmical normal distribution.

The determined characteristic value for specimen with equilibrium moisture content at normal climate conditions in accordance with EN 408 of about 12 % applies if the hybrid glulam and the GLVL-FJ are only used in service class 1. In the case that the hybrid glulam and the GLVL-FJ are intended to be used in service class 2 the characteristic value shall be decreased by the factor 0,8 (see EN 384, clause 5.4.2). Optionally, the test may be carried out with specimen with 16 % ± 2 % moisture content.

Table 2.2.5.2.1 Specification of the determination of the compression strength parallel to grain

Tests of the hybrid glulam and GLVL-FJ	Test method	Specimen type	Minimum Number
Compression strength parallel to grain $f_{c,0,k}$	EN 408, clause 15	Smallest cross-sectional height	15 per LVL product, strengthening level, glulam strength class, finger joint adhesive and finger joint press

2.2.5.3 Compression strength parallel to grain of hybrid glulam – Elastic composite beam theory

As simplified method the characteristic compression strength parallel to the grain fc,0,k of hybrid glulam and shall be determined using the principles of the elastic composite beam theory in accordance with Annex C.6 from:

- the compression strength $f_{c,0,g,k}$ and the modulus of elasticity parallel to the grain $E_{0,g,mean}$ of solid glulam (see clause 2.2.1.1) and
- the compression strength $f_{c,0,l,LVL,k}$ (see clause 2.2.1.2) and the mean modulus of elasticity parallel to the grain $E_{0,l,LVL,mean}$ of the LVL laminations (see clause 2.2.1.2).

2.2.5.4 Compressive strength parallel to grain of GLVL-FJ

The characteristic compressive strength parallel to grain of GLVL-FJ shall be taken as the compressive strength parallel to the grain of the LVL laminations fc,0,l,LVL,k(see clause 2.2.1.2).

2.2.6 Compression strength perpendicular to the grain

2.2.6.1 Compression perpendicular to the glue-lines between the laminations

The characteristic compression strength perpendicular to the grain fc,90,flat,k for stresses perpendicular to the glue-lines between the laminations is taken as the characteristic compression strength perpendicular to the grain of the solid timber glulam (only for hybrid glulam) fc,90,g,k (see clause 2.2.1.1) and the characteristic flatwise compression strength perpendicular to the grain of the LVL laminations fc,90,flat,LVL,k.

For the solid timber glulam part of hybrid glulam a characteristic compression strength perpendicular to the grain of $f_{c,90,g,k}$ = 2,5 N/mm^2 shall be taken.

For the LVL part of hybrid glulam and for GLVL-FJ the characteristic flatwise compression strength perpendicular to the grain $f_{c,90,flat,LVL,k}$ shall be determined in accordance with EN 14374, clause 4.4.7. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

The characteristic compression strength perpendicular to the grain $f_{c,90,flat,k}$ for stresses perpendicular to the glue-lines between the laminations shall be given in the ETA.

2.2.6.2 Compression parallel to the glue-lines between the laminations

2.2.6.2.1 General

In the following methods to assess the characteristic edgewise compression strength perpendicular to the grain fc,90,edge,k of hybrid glulam and GLVL-FJ are given. The assessment method for hybrid glulam is given in clause 2.2.6.2.2. The assessment method for GLVL-FJ is given in clause 2.2.6.2.3.

The characteristic tensile strength of hybrid glulam or GLVL-FJ fc,90,edge,k shall be given in the ETA.

2.2.6.2.2 Compression strength perpendicular to grain - parallel to the glue-lines between the laminations of hybrid glulam – Elastic composite beam theory

The characteristic edgewise compression strength perpendicular to the grain $f_{c,90,edge,k}$ of hybrid glulam for stresses parallel to the glue-lines between the laminations shall be determined using the principles of the elastic composite beam theory in accordance with Annex C.7 from

- the characteristic compression strength perpendicular to the grain of the solid timber glulam $f_{c,90,g,k}$, where $f_{c,90,g,k}$ shall be taken as 2,5 N/mm² and the mean modulus of elasticity perpendicular to the grain $E_{90,mean}$ of solid glulam, in accordance with EN 14080, Tables 4 or 5, whichever is applicable, and
- the characteristic edgewise compression strength perpendicular to the grain $f_{c,90,edge,LVL,k}$ of the LVL laminations, which shall be determined in accordance with EN 14374, clause 4.4.7, and the mean modulus of elasticity $E_{90,edge,LVL,mean}$. If there is a declaration of performance of the LVL in accordance with EN 14374, $f_{c,90,edge,LVL,k}$ and $E_{90,edge,LVL,mean}$ shall be taken from the declaration of performance, if declared.

2.2.6.2.3 Compression strength perpendicular to grain - parallel to the glue-lines between the laminations of GLVL-FJ

For GLVL-FJ the characteristic edgewise compression strength perpendicular of the grain $f_{c,90,edge,k}$ is taken as the characteristic edgewise compression strength perpendicular to the grain $f_{c,90,edge,LVL,k}$ of the LVL laminations, which shall be determined in accordance with EN 14374, clause 4.4.7. If there is a declaration of performance of the LVL in accordance with EN 14374, $f_{c,90,edge,LVL,k}$ shall be taken from the declaration of performance, if declared.

2.2.7 Shear strength

The characteristic shear strength of hybrid glulam fv,k shall be taken as 3,5 N/mm² as given in EN 14080, Table 6. The characteristic shear strength of hybrid glulam fv,k shall be given in the ETA.

The characteristic shear strength of GLVL-FJ in flatwise orientation fv,flat,k shall be taken as the characteristic shear strength of the LVL laminations in flatwise bending fv,0,flat,LVL,,k in accordance with EN 14374, clause 4.4.9, multiplied with a size effect factor

ksize,shear,GLVL_FJ = min ((300/H)s;1) (2.2.7.1)

with

H depth of the GLVL-FJ

s size effect parameter

$s = 2 \cdot COV - 0{,}05$ (2.2.7.2)

where

COV is the coefficient of variation of the test results, which shall be larger than or equal to 0,10.

Regarding sampling and number of specimens EN 14374, clause 5.2.2 shall be considered. If the size effect parameter s is unknown it shall be taken as s = 0,15.

The characteristic shear strength of GLVL-FJ in edgewise orientation fv,edge,k shall be taken as the characteristic shear strength of the LVL laminations in edgewise bending fv,0,edge,LVL,k in accordance with EN 14374, clause 4.4.8. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

The characteristic shear strength of GLVL-FJ fv,flat,k and fv,edge,k shall be given in the ETA.

2.2.8 Rolling shear strength

The characteristic rolling shear strength of hybrid glulam shall be taken as $f_{r,k}$ = 1,2 N/mm² in accordance with EN 14080, Table 4.

The characteristic rolling shear strength of GLVL-FJ $f_{r,k}$ shall be taken as the characteristic shear strength of the LVL laminations in flatwise bending $f_{v,90,flat,LVL,k}$ in accordance with EN 14374, clause 4.4.9. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

The characteristic rolling shear strength $f_{r,k}$ shall be given in the ETA.

2.2.9 Modulus of elasticity parallel to the grain

2.2.9.1 General

In the following methods to assess the modulus of elasticity (MOE) parallel to the grain $E_{m,0,mean}$ and $E_{m,0,05}$ of hybrid glulam and $E_{0,GLVL\text{-}FJ,\ mean}$ and $E_{0,GLVL\text{-}FJ,05}$ of GLVL-FJ are given, i.e., full-scale testing (clause 2.2.9.2) as reference method for hybrid glulam and GLVL-FJ and, alternatively, one simplified method for symmetrical hybrid glulam (clause 2.2.9.3) and one for GLVL-FJ (clause 2.2.9.4). One of the two assessment methods given in clauses 2.2.9.2 and 2.2.9.3/ 2.2.9.4 can be used where the full-scale tests are the reference method.

The modulus of elasticity parallel to the grain of hybrid glulam or GLVL-FJ shall be given in the ETA together with the information about the assessment method used. The mean and the fifth percentile value of the modulus of elasticity parallel to the grain $E_{m,0,mean}$ and $E_{m,0,05}$ for hybrid glulam and $E_{0,GLVL\text{-}FJ,\ mean}$ and $E_{0,GLVL\text{-}FJ,05}$ for GLVL-FJ shall be given in the ETA.

2.2.9.2 Modulus of elasticity parallel to the grain of hybrid glulam and GLVL-FJ determined from full-scale tests as reference method

As reference method for hybrid glulam and GLVL-FJ the modulus of elasticity parallel to the grain $E_{m,0}$ and $E_{0,GLVL\text{-}FJ}$ shall be determined from full-scale tests in accordance with Table 2.2.9.2.1.

The specimens shall be tested in flatwise bending in accordance with EN 14080, Annex F, whereby the location of finger joints (in case of finger-jointed LVL laminations) is given in Figure 2.2.1.5.2.1. The finger joints of finger-jointed LVL laminations shall be randomly distributed as in usual industrial production and shall conform with the following provision: every tested specimen should exhibit at least one finger joint in the outer lamination at the tension edge of the cross-section within the zone of constant bending moment. The mean value and the characteristic value of the modulus of elasticity parallel to the grain shall be calculated from the individual modulus of elasticity values in accordance with EN 14358, clauses 3.2 and 3.3.

Table 2.2.9.2.1 Specification of the determination of the modulus of elasticity parallel to the grain of the hybrid glulam and GLVL-FJ

Tests of the hybrid glulam and GLVL-FJ	**Test method**	**Minimum Number**
Modulus of elasticity parallel to the grain $E_{m,0}$ and $E_{0,GLVL\text{-}FJ}$	EN 14080, Annex F	7 per LVL product, strengthening level, glulam strength class

Note: The determination of MOE for asymmetrical hybrid glulam is mostly performed together with the bending strength tests in accordance with clause 2.2.1.5.

2.2.9.3 Modulus of elasticity parallel to the grain Em,0 of symmetrical hybrid glulam – Elastic composite beam theory

As simplified method the modulus of elasticity parallel to the grain Em,0 of symmetrical hybrid glulam shall be determined using the principles of the elastic composite beam theory in accordance with Annex C.8 from

- modulus of elasticity $E_{0,g,}$ of solid timber glulam (for symmetrical hybrid glulam only, see clause 2.2.1.1) and
- modulus of elasticity $E_{0,l,LVL}$ of LVL laminations (see clause 2.2.1.2).

The method applies for $E_{m,0,mean}$ and $E_{m,0,05}$ equally. The mean and the fifth percentile value of the modulus of elasticity parallel to the grain $E_{m,0,mean}$ and $E_{m,0,05}$ shall be given in the ETA.

2.2.9.4 Modulus of elasticity parallel to the grain of GLVL-FJ

As simplified method the modulus of elasticity parallel to the grain of the GLVL-FJ $E_{0,GLVL-FJ,}$ shall be taken as the modulus of elasticity parallel to the grain of the LVL laminations $E_{0,LVL}$.

2.2.10 Modulus of elasticity perpendicular to the grain

2.2.10.1 Perpendicular to the glue-lines between the laminations

2.2.10.1.1 General

In the following methods to assess the modulus of elasticity perpendicular to the grain - perpendicular to the glue-lines between the laminations - Em,90, flat,mean and Em,90,flat,05 of hybrid glulam and E90,flat,GLVL-FJ,mean and E90,flat,GLVL-FJ,05 of GLVL-FJ are given. The assessment method for hybrid glulam is given in clause 2.2.10.1.2. The assessment method for GLVL-FJ is given in clause 2.2.10.1.3.

2.2.10.1.2 Modulus of elasticity perpendicular to the grain Em,90,flat of hybrid glulam – Elastic composite beam theory

For hybrid glulam the modulus of elasticity perpendicular to the grain for stresses perpendicular to the glue-lines between the laminations E90,flat,mean and E90,flat,05 shall be determined using the principles of the elastic composite beam theory in accordance with Annex C.8 from the modulus of elasticity perpendicular to the grain E90,g in accordance with EN 14080 of the solid timber glulam (see clause 2.2.1.1) and the modulus of elasticity perpendicular to the grain E90,flat,LVL in accordance with EN 14374, clause 4.5.3, of the LVL laminations. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

2.2.10.1.3 Modulus of elasticity perpendicular to the grain of GLVL-FJ

For GLVL-FJ the modulus of elasticity perpendicular to the grain for stresses perpendicular to the glue-lines between the laminations E90,flat,GLVL-FJ shall be taken as the modulus of elasticity perpendicular to the grain E90,flat,LVL in accordance with EN 14374, clause 4.5.3, of the LVL laminations. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

The method applies for $E_{90,flat,GLVL-FJ,mean}$ and $E_{90,flat,GLVL-FJ,05}$ equally.

2.2.10.2 Parallel to the glue-lines between the laminations

2.2.10.2.1 General

In the following methods to assess the modulus of elasticity perpendicular to the grain - parallel to the glue-lines between the laminations - $E_{m,90,flat,mean}$ and $E_{m,90,flat,05}$ of hybrid glulam and $E_{90,flat,GLVL-FJ,mean}$ and $E_{90,flat,GLVL-FJ,05}$ of GLVL-FJ are given. The assessment method for hybrid glulam is given in clause 2.2.10.2.2 The assessment method for GLVL-FJ is given in clause 2.2.10.2.3.

The modulus of elasticity perpendicular to the grain of hybrid glulam or GLVL-FJ shall be given in the ETA. The mean and the fifth percentile value of the modulus of elasticity perpendicular to the grain - perpendicular to the glue-lines between the laminations - $E_{m,90,flat,mean}$ and $E_{m,90,flat,05}$ for hybrid glulam and $E_{90,flat,GLVL\text{-}FJ,\,mean}$ and $E_{90,flat,GLVL\text{-}FJ,05}$ for GLVL-FJ shall be given in the ETA.

2.2.10.2.2 Modulus of elasticity perpendicular to the grain Em,90,flat of hybrid glulam – Elastic composite beam theory

For hybrid glulam the modulus of elasticity perpendicular to the grain for stresses parallel to the glue-lines between the laminations Em,90,edge shall be determined using the principles of the elastic composite beam theory in accordance with Annex C.8 from

– the modulus of elasticity perpendicular to the grain $E_{90,g}$ in accordance with EN 14080 of the solid timber glulam (see clause 2.2.1.1) and
– the modulus of elasticity perpendicular to the grain $E_{90,edge,LVL}$ in accordance with EN 14374, clause 4.5.3, of the LVL laminations. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

2.2.10.2.3 Modulus of elasticity perpendicular to the grain of GLVL-FJ

For GLVL-FJ the modulus of elasticity perpendicular to the grain for compression stresses parallel to the glue-lines between the laminations $E_{90,edge,GLVL\text{-}FJ}$ shall be taken as the modulus of elasticity perpendicular to the grain $E_{90,edge,LVL}$ in accordance with EN 14374, clause 4.5.3, of the LVL laminations.

The method applies for $E_{90,edge,GLVL\text{-}FJ,mean}$ and $E_{90,edge,GLVL\text{-}FJ,05}$ equally.

2.2.11 Shear modulus

The shear moduli of hybrid glulam Gmean and G05 shall be taken as the lower value of the shear modulus Gg of solid timber glulam and the shear modulus G0,flat,LVL of LVL laminations.

The shear moduli of GLVL-FJ for flatwise bending Gflat,mean and Gflat,05 shall be taken as the shear moduli Gflat,LVL,mean and Gflat,LVL,05 of the LVL laminations determined as given in EN 14374, clause 4.5.5. The shear moduli of GLVL-FJ for edgewise bending Gedge,mean and Gedge,05 shall be taken as the shear moduli Gedge,LVL,mean and Gedge,LVL,05 of the LVL laminations determined as given in EN 14374, clause 4.5.4. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

The mean and the fifth percentile value of the shear moduli Gflat,mean, Gflat,05 and Gedge,mean and Gedge,05 shall be given in the ETA.

2.2.12 Rolling shear modulus

The rolling shear moduli $G_{r,mean}$ and $G_{r,05}$ of hybrid glulam shall be taken as $G_{r,g,mean}$ = 65 N/mm² and $G_{r,g,05}$ = 54 N/mm² in accordance with EN 14080, Table 4.

The rolling shear moduli $G_{r,mean}$ and $G_{r,05}$ of GLVL-FJ shall be taken as the shear moduli $G_{90,flat,LVL,mean}$ and $G_{90,flat,LVL,05}$ of the LVL laminations determined as given in EN 14374, clause 4.5.5. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

The mean and the fifth percentile value of the rolling shear moduli $G_{r,mean}$ and $G_{r,05}$ shall be given in the ETA.

2.2.13 Density

The mean and characteristic density □mean□□and□□k of hybrid glulam shall be taken as the mean or characteristic density of the solid timber glulam in accordance with Table 4, Table 5 or Table 6 of EN 14080 or as set out in EN 14080, clause 5.1.5.3, respectively. For LVL laminations the mean and characteristic density according to EN 14374, clause 4.6, shall be used.

The mean and characteristic density □mean□□and□□k of GLVL-FJ shall be taken as the mean or characteristic density of the LVL laminations in accordance with EN 14374, clause 4.6, respectively. Regarding sampling and number of specimens EN 14374, clause 5.2.2, shall be considered.

The mean and characteristic density □mean□□and□□k shall be given in the ETA.

2.2.14 Dimensional stability

The dimensional stability shall be assessed as swelling and shrinkage values of the GLVL-FJ in length L, thickness H and width B directions. The GLVL-FJ shall be tested in accordance with EN 318 for every species or species combinations. Change in the width is tested similar to the change of length in accordance with EN 318. The swelling and shrinkage factor α_H is the mean value of percentile change of dimension related to one percent change in moisture content under the wood fibre saturation point for each tested GLV-FJ in length L, thickness H and width B directions. It is calculated as

$$\alpha_{\mathrm{H,L}} = \frac{1}{2} \cdot \left(\frac{\delta l_{65,85,\mathrm{mean}}/10}{\omega_{85,1,\mathrm{mean}} - \omega_{65,1,\mathrm{mean}}} + \frac{\delta l_{65,30,\mathrm{mean}}/10}{\omega_{30,2,\mathrm{mean}} - \omega_{65,2,\mathrm{mean}}} \right) \quad (2.2.14.1)$$

$$\alpha_{\mathrm{H,B}} = \frac{1}{2} \cdot \left(\frac{\delta b_{65,85,\mathrm{mean}}/10}{\omega_{85,1,\mathrm{mean}} - \omega_{65,1,\mathrm{mean}}} + \frac{\delta b_{65,30,\mathrm{mean}}/10}{\omega_{30,2,\mathrm{mean}} - \omega_{65,2,\mathrm{mean}}} \right) \quad (2.2.14.2)$$

$$\alpha_{\mathrm{H,H}} = \frac{1}{2} \cdot \left(\frac{\delta t_{65,85,\mathrm{mean}}}{\omega_{85,1,\mathrm{mean}} - \omega_{65,1,\mathrm{mean}}} + \frac{\delta t_{65,30,\mathrm{mean}}}{\omega_{30,2,\mathrm{mean}} - \omega_{65,2,\mathrm{mean}}} \right) \quad (2.2.14.3)$$

where

$\alpha_{H,L}$ = Swelling and shrinkage factor in length direction [% / 1% change of moisture content];

$\alpha_{H,B}$ = Swelling and shrinkage factor in width direction [% / 1% change of moisture content];

$\alpha_{H,H}$ = Swelling and shrinkage factor in thickness direction [% / 1% change of moisture content];

$\delta_{L65,30,mean}$ = Mean value of the relative change of length defined in EN 318 for a change of the relative humidity from 65 % to 30 %, in millimetres per metre;

$\delta_{L65,85,mean}$ = Mean value of the relative change of length defined in EN 318 for a change of the relative humidity from 65 % to 85 %, in millimetres per metre;

$\delta_{B65,30,mean}$ = Mean value of the relative change of width defined similar to length in EN 318 for a change of the relative humidity from 65 % to 30 %, in millimetres per metre;

$\delta_{B65,85,mean}$ = Mean value of the relative change of width defined similar to length in EN 318 for a change of the relative humidity from 65 % to 85 %, in millimetres per metre;

$\delta_{H65,30,mean}$ = Mean value of the relative change of thickness defined in EN 318 for a change of the relative humidity from 65 % to 30 %, in percent;

$\delta_{H65,85,mean}$ = Mean value of the relative change of thickness defined in EN 318 for a change of the relative humidity from 65 % to 85 %, in percent;

$\omega_{85,1,mean}$ = Mean value of the moisture content of the test pieces as defined in EN 322 of the set 1 as defined in EN 318 in relative humidity of 85 %;

$\omega_{65,1,mean}$ = Mean value of the moisture content of the test pieces as defined in EN 322 of the set 1as defined in EN 318 in relative humidity of 65 %;

$\omega_{30,2,mean}$ = Mean value of the moisture content of the test pieces as defined in EN 322 of the set 2 as defined in EN 318 in relative humidity of 30 %;

$\omega_{65,2,mean}$ = Mean value of the moisture content of the test pieces as defined in EN 322 of the set 2 in relative humidity of 65 %;

For simplification the swelling and shrinkage values of GLVL-FJ shall be used for hybrid glulam.

Swelling and shrinkage factors α_H of GLVL-FJ and hybrid glulam in length L, thickness H and width B directions as percentile change of dimension related to one percent change in moisture content under the wood fibre saturation point shall be given in the ETA.

2.2.15 Reaction to fire

One of the following options shall apply for the assessment of the reaction to fire performance of hybrid glulam and GLVL-FJ:

a) In case that both materials of the hybrid glulam with hybrid lay-up (including block-glued hybrid glulam) fulfil the following conditions:

- the glulam made of solid softwood laminations is considered to satisfy the requirements of class D-s2, d0 of the reaction-to-fire performance in accordance with the Commission Delegated Regulation (EU) 2017/1227 without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision;

  and

- the glulam made of LVL is considered to satisfy the requirements of class D-s2, d0 of the reaction-to-fire performance in accordance with the Commission Delegated Regulation (EU) 2017/2293 without the need for testing on the basis of fulfilling the conditions set out in that Decision and its intended use being covered by that Decision;

the performance of the hybrid glulam is considered as class D-s2, d0 for the characteristic reaction to fire without the need for testing and shall be stated in the ETA.

b) Glulam solely made of laminated veneer lumber (GLVL-FJ) with symmetrical lay-up and block-glued hybrid glulam solely made of GLVL-FJ is considered to satisfy the requirements of class D-s2, d0 of the reaction-to-fire performance in accordance with the Commission Delegated Regulation (EU) 2017/2293 without the need for testing on the basis of fulfilling the conditions set out in that Decision and its intended use being covered by that Decision.

   Therefore, the performance of these products is class D-s2, d0 and shall be stated in the ETA.

c) If neither option "a)" nor option "b)" apply or a better classification is sought, the glulam with hybrid or homogeneous lay-up and block-glued glulam shall be tested, using the test method(s) relevant for the corresponding reaction to fire class in accordance with EN 13501-1. The glulam with hybrid or homogeneous lay-up and block-glued glulam shall be classified in accordance with Commission Delegated Regulation (EU) No 2016/364 in connection with EN 13501-1.

If option "c)" applies, for the mounting and fixing conditions of the specimens for the tests in accordance with EN 13823 (SBI) the provisions in EN 14080, clause 5.8, shall apply. Tests in accordance with EN ISO 11925-2 shall be conducted on free-hanging specimens without using an additional substrate.

If joints of block gluing or finger joints are foreseen for the final product, the specimens for the SBI tests shall be prepared in such manner, that such joint is positioned in vertical direction on the long wing of each test specimen with a distance of 200 mm to the inner corner of the specimens. Joints of block gluing and finger joints shall be tested separately by at least one orientation test for both variants.

For tests in accordance with EN ISO 11925-2 the specimens shall be prepared in such way that flame exposure is possible at the following points:

– non-interrupted area of the wood of the glulam,

– non-interrupted area of the LVL,

– glued joint with the maximum joint width as well as finger joint in the vertical middle axis of at least two specimens for each variant.

Results of these tests are valid for glulam with hybrid or homogeneous lay-up and block-glued glulam produced (considering the aforementioned provisions and conditions entirely).

– with the same combination of wood species used for glulam and LVL laminations as tested,

- with the same ratio of glulam and LVL as tested or the range between highest and lowest ratio of glulam and LVL as tested,
- with the same adhesive with equal or lower visible area per square meter of glued joints as used for the preparation of the tested specimens,
- with equal or lower width of the glued joints,
- with the same or higher thickness than tested,
- with the same or higher apparent minimum density ($\rho_{hybrid,mean}$).

2.2.16 Resistance to fire

The fire resistance of GLVL-FJ for criteria R, E or I or a combination of these criteria shall be tested according to the relevant method(s), i.e., EN 1365-3 for beams and EN 1365-2 for floors and roofs, and classified according to EN 13501-2. All boundary conditions of the test that have an influence on the fire resistance shall be stated in the ETA in accordance with EN 1363-1, clause 12. The field of direct application of the test results shall also be stated in the ETA in accordance with the relevant test standard.

2.2.17 Content, emission and/or release of dangerous substances

2.2.17.1 General

The performance of the product related to the emissions and/or release and, where appropriate, the content of dangerous substances shall be assessed on the basis of the information provided by the manufacturer5 after identifying the release scenarios taking into account the intended use of the product and the Member States where the manufacturer intends his product to be made available on the market.

The identified intended release scenarios for this product and intended use with respect to dangerous substances are:

IA1: Product with direct contact to indoor air
IA2: Product with indirect contact to indoor air (e.g., covered products) but possible impact on indoor air.

2.2.17.2 Formaldehyde emission

If a formaldehyde-containing adhesive is used to produce glulam with hybrid or homogeneous lay-up and block-glued glulam (including the finger joints), the release of formaldehyde shall be determined in accordance with EN 14080, Annex A.

If formaldehyde-free adhesives are used to produce glulam with hybrid or homogeneous lay-up and block-glued glulam (including the finger joints), the release of formaldehyde shall be assigned to class E1 without testing in accordance with EN 14080, Annex A.

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[5] The manufacturer may be asked to provide to the TAB the REACH related information which shall accompany the DoP (cf. Article 6(5) of Regulation (EU) No 305/2011).

The manufacturer is **not** obliged to:
- provide the chemical constitution and composition of the product (or of constituents of the product) to the TAB, or
- provide a written declaration to the TAB stating whether the product (or constituents of the product) contain(s) substances which are classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and listed in the "Indicative list on dangerous substances" of the SGDS, taking into account the installation conditions of the construction product and the release scenarios resulting from there.

Any information provided by the manufacturer regarding the chemical composition of the products is not to be distributed to EOTA, to other TABs or beyond.

The release of formaldehyde is stated as class E1 or E2.

2.2.18 Durability of bonding strength

2.2.18.1 General

The durability of bonding strength of glulam with hybrid or homogeneous lay-up and block-glued glulam shall be assessed by tests specified in the following clauses 2.2.18.2 to 2.2.18.7. For the tests 5 beams with the largest cross-sectional dimensions as to be covered by the ETA or with a width of 600 mm and a depth of 150 mm, whichever is greater, shall be produced. Slabs from 2 positions of each beam shall be taken for the tests; thus, for every test at least 10 specimens shall be tested.

For the different product types tests shall be performed in accordance with the following clauses as specified in Table 2.2.18.1.1.

Table 2.2.18.1.1 Specification of tests for the assessment of the durability of bonding strength for glulam with hybrid or homogeneous lay-up and block-glued glulam

Cross-sectional lay-up/ Laminations	**Type of Block-Gluing**			
	without block glue-lines	with block glue-lines of type i)*	with block glue-lines of type ii)*	with block glue-lines of type iii)*
Hybrid glulam with one LVL lamination	2.2.18.2 and 2.2.18.4	2.2.18.2, 2.2.18.4 and 2.2.18.5.b	2.2.18.2, 2.2.18.4 and 2.2.18.6	2.2.18.2, 2.2.18.4 and 2.2.18.7.b
Hybrid glulam with two or more LVL laminations	2.2.18.2, 2.2.18.3 and 2.2.18.4	2.2.18.2, 2.2.18.3, 2.2.18.4 and 2.2.18.5.b	2.2.18.2, 2.2.18.3, 2.2.18.4 and 2.2.18.6	2.2.18.2, 2.2.18.3, 2.2.18.4 and 2.2.18.7.b
GLVL-FJ	2.2.18.3	2.2.18.3 and 2.2.18.5.a	--	2.2.18.3 and 2.2.18.7.a

* For definition of block glue-line types see Figure 1.1.4.1

2.2.18.2 Durability of bonding strength of the glued laminated timber – Glue-lines between solid timber laminations

The durability of bonding strength of the glue-lines between the solid timber laminations shall be assessed by delamination tests in accordance with EN 14080, Annex C, method A. In the ETA it shall be stated whether the provisions of EN 14080, Table 9 are met.

2.2.18.3 Durability of bonding strength of the glued laminated timber – Glue-lines between LVL laminations

The durability of bonding strength of the glue-lines between the LVL laminations shall be assessed by cleavage tests in accordance with EN 14374, Annex B. In the ETA it shall be stated whether the provision of EN 14374, clause 4.2 is met.

2.2.18.4 Durability of bonding strength of the glued laminated timber – Hybrid glue-lines between solid timber and LVL laminations

The durability of bonding strength of the hybrid glue-line between solid timber and LVL laminations shall be assessed by the modified block shear test method specified in Annex A. In the case that the relative block shear strength rel fv,block falls below 0,7, the product is not covered by this EAD.

2.2.18.5 Durability of bonding strength of block-glued hybrid glulam and block-glued GLVL-FJ – Block glue-line type i)

2.2.18.5.a Block-glued GLVL-FJ

The block glue-line shall be tested by cleavage tests in accordance with EN 14374, Annex B. In the ETA it shall be stated whether the provision of EN 14374, clause 4.2 is met. For technical reasons (capacity of test equipment) the cross-sectional slabs can be cut to smaller pieces with the block glue-line in the centre.

2.2.18.5.b Block-glued hybrid glulam

The cross-sectional slabs shall be cut into two parts at the hybrid glue-line between the solid timber and LVL lamination.

The durability of bonding strength of the block glue-line(s) in the part with solid timber laminations shall be assessed by delamination tests in accordance with EN 14080, Annex C, method A. In the ETA it shall be stated whether the provisions of EN 14080, Table 9 are met. For technical reasons (capacity of test equipment) the cross-sectional slabs may be cut to smaller pieces with the block glue-line in the centre.

The durability of bonding strength of the block glue-line(s) in the part with LVL lamination(s) shall be assessed by cleavage tests in accordance with EN 14374, Annex B. In the ETA it shall be stated whether the provision of EN 14374, clause 4.2 is met.

2.2.18.6 Durability of bonding strength of block-glued hybrid glulam – Block glue-line type ii)

The durability of bonding strength of the hybrid block glue-line shall be assessed by modified block shear test method specified in Annex A. In the case that the relative block shear strength rel $f_{v,block}$ falls below 0,7, the product is not covered by this EAD.

2.2.18.7 Durability of bonding strength of the block-glued hybrid glulam and block-glued GLVL-FJ – Block glue-line type iii)

2.2.18.7.a Block-glued GLVL-FJ

Clause 2.2.18.5.a applies.

2.2.18.7.b Block-glued hybrid glulam

The durability of bonding strength of the block glue-line shall be assessed by delamination tests in accordance with EN 14080, Annex C, method A. In the ETA it shall be stated whether the provisions of EN 14080, Table 9, are met.

2.2.19 Durability against biological attack

The natural durability against biological attack of the glulam with hybrid or homogeneous lay-up and block-glued glulam shall be assessed in accordance with EN 350, clause 5.2 and Annex B. The durability classes in accordance with EN 350, clause 5.2, of the glulam with hybrid or homogeneous lay-up and block-glued glulam shall be given in the ETA.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Commission Decision 97/176/EC, as amended by Commission Decision 2001/596/EC.

The system is 1.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

Table 3.2.1 Control plan for the manufacturer; cornerstones

No	Subject / type of control		Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]						
Mechanical resistance, stiffness and density						
1	Strength, stiffness and density properties of the lami-nations made of	Solid timber	EN 14080, clause 5.1	See control plan	-	See control plan
		LVL	EN 14374, clause 4	See control plan		
2	Species, adhesives		Checking of suppliers certificate	Check whether the incoming material is within the conditions given in 1.1	-	For each delivery
3	Moisture content of components to be jointed	Solid timber in hybrid glulam	EN 14080, Annex G	EN 14080, Annex I	-	Continuously, every piece
		LVL in GLVL-FJ or in hybrid glulam	EN 14374, clause 4.7	For all lay-ups: The moisture content values of LVL laminations glued together shall not differ more than 5%-points. For hybrid lay-up: Difference between mean value of the moisture ranges of LVL and solid wood glulam shall be smaller than 5%-points.	2 taken at random	Per shift
		Hybrid glulam or GLVL-FJ in case of block-gluing	EN 14080, Annex G or EN 14374, Annex 4.7	Difference between mean value of the moisture ranges of LVL or solid wood glulam shall be smaller than 5%-points.		
4	Temperature of the timber	Solid timber and LVL	EN 14080, Annex I.4.8 and I.5.10	EN 14080, Annex I.4.8 and I.5.10	-	Continuously during production
		Block-glued hybrid glulam and block-glued GLVL-FJ	EN 14080, Annex I.4.8 and I.7.5	EN 14080, Annex I.4.8 and I.7.5	-	Continuously during production
5	Glue line thickness	Solid timber and LVL	EN 14080, Annex I.5.8	EN 14080, Annex I.5.8	-	daily
		Block-glued hybrid glu-lam EN 301 I 90 GF 1,5M	EN 14080, Annex I.7.4	EN 14080, Annex I.7.4	-	daily

No	Subject / type of control			Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
			EN 301 I 90 GP 0,6	EN 14080, Annex I.7.4	≤ 0,5 mm	-	daily
		Block-glued GLVL-FJ		EN 14080, Annex I.7.4	EN 14080, Annex I.7.4	-	daily
6	Cramping pressure for face-gluing			Checking whether the required cramping pressure is maintained in the curing process	Ensure that the cramping pressure is adapted to the raw density of the laminations	-	daily
7	Cramping pressure for block-glued hybrid glulam and block-glued GLVL-FJ			Checking whether the required cramping pressure is maintained in the curing process	EN 14080, Annex I.7.3	-	daily
8	Bending strength of laminations with finger joints			EN 14080, Annex E	See control plan	2 samples taken at random for each strength class or characteristic bending strength, species and adhesive	• 2 joints in solid wood laminations per shift, wood species and production line • 2 joints in LVL laminations per shift, wood species and production line (if relevant)
9	Geometrical data	For hybrid glulam and block-glued hybrid glulam		EN 14080, clause 5.11.1 including the measurement of the moisture content in accordance with EN 14080, Annexes G.1 and G.3, and EN 14374, 4.7	EN 14080, clause 5.11.1	2 taken at random	2 per shift
		For GLVL-FJ and block-glued GLVL-FJ		EN 14374, clause 4.3 including the measurement of the moisture content in accordance with EN 14374, 4.7	EN 14374, clause 4.3		
10	Bonding strength	Glue-lines and block glue-lines type i) between solid timber laminations		EN 14080, Annex C, method B	EN 14080, Table 9	one full cross-sectional specimen for each 20 m^3 of production	1 per shift
		Glue-lines and block glue-lines type i) and iii) between LVL laminations		EN 14374, Annex B	EN 14374, clause 4.2		

No	Subject / type of control		Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
		Hybrid glue-lines between solid timber and LVL laminations and block glue-lines type ii)	Annex B	See control plan		
		Block glue-line type iii) between solid timber	EN 14080, Annex C, method B	EN 14080, Table 9		
		Glue-line thickness	EN 14080, Annex I.5.8	EN 14080, Annex I.5.8		
		Block glue-line thickness	EN 14080, Annex I.7.4	EN 14080, Annex I.7.4		
Safety in case of fire						
11	Reaction to fire		<u>Clause 2.2.15 a) and b):</u> Check the relevant indirect parameters. • minimum thickness of the laminations, veneers, if relevant and of the component, • apparent minimum density Clause 2.2.15 c): Check that all relevant indirect parameters: • minimum thickness of the laminations, veneers, if relevant and of the component, • apparent minimum density, • wood species • type of adhesive and its coverage as determined within the reaction to fire tests are fulfilled	The provisions of the relevant Delegated Regulation (EU) 2017/1227 and Delegated Regulation (EU) 2017/2293 shall be fulfilled See control plan	1	Per shift
Content, emission and/or release of dangerous substances						
12	Formaldehyde emission		EN 14080, clause 5.9	Class E1 or E2		Control at any reception of adhesives that only adhesives for which an initial classification has been carried out within the assessment of the performance are used

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.3.1.

Table 3.3.1 Control plan for the notified body; cornerstones

No	Subject / type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	Ascertain that the factory production control with the staff and equipment is suitable to ensure a continuous and orderly manufacturing of the product considering particularly the following inspections and in accordance with EN 14080, Annex I.1 to I.5 and Annex I.7: – Suitable premises – Suitable technical equipment – Qualified personnel – Suitability of the factory production control established by the manufacturer – Full implementation of the control plan	Verification of the complete FPC, to be implemented by the manufacturer as defined in the control plan	-	-	When starting the production process or when starting a new production line
Continuous surveillance, assessment and evaluation of factory production control					
2	Ascertain that the system of factory production control and the specified automated manufacturing process are maintained in accordance with EN 14080, Annex I.1 to I.5 and Annex I.7, and as defined in the control plan	Verification of the controls carried out by the manufacturer on the raw materials, on the manufacturing process and on the product as indicated in Table 3.2.1 and as defined in the control plan	-	-	Twice a year

4 REFERENCE DOCUMENTS

EN 301:2023	Adhesives, phenolic and aminoplastic, for load-bearing timber structures – Classification and performance requirements
EN 318:2002	Wood based panels - Determination of dimensional changes associated with changes in relative humidity
EN 322:1993	Wood-based panels - Determination of moisture content
EN 338:2016	Structural timber – Strength classes
EN 350:2016	Durability of wood and wood-based products – Testing and classification of the durability to biological agents of wood and wood-based materials
EN 384:2016+A2:2022	Structural timber – Determination of characteristic values of mechanical properties and density
EN 408:2010+A1:2012	Timber structures – Structural timber and glued laminated timber – Determination of some physical and mechanical properties
EN 1363-1:2020	Fire resistance tests - Part 1: General requirements
EN 1365-2:2014	Fire resistance tests for loadbearing elements - Part 2: Floors and roofs
EN 1365-3:1999	Fire resistance tests for loadbearing elements - Part 3: Beams
EN 1995-1-1: 2004+AC: 2006+A1:2008+A2:2014	Eurocode 5: Design of timber structures – Part 1-1: General – Common rules and rules for buildings
EN 1995-1-2:2004+ AC:2009	Eurocode 5: Design of timber structures – Part 1-2: General – Structural fire design
EN 13501-1:2018	Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests
EN 13501-2:2023	Fire classification of construction products and building elements – Part 2: Classification using data from fire resistance and/or smoke control tests, excluding ventilation services
EN 13823:2020+A1:2022	Reaction to fire tests for building products – Building products excluding floorings exposed to the thermal attack by a single burning item
EN 14080:2013	Timber structures – Glued laminated timber and glued solid timber – Requirements
EN 14081-1: 2005+A1:2011	Timber structures – Strength graded structural timber with rectangular cross section – Part 1: General requirements
EN 14358:2016	Timber structures – Calculation and verification of characteristic values
EN 14374:2004	Timber structures – Structural laminated veneer lumber – Requirements
EN 15425:2023	Adhesives – One component polyurethane (PUR) for load-bearing timber structures – Classification and performance requirements
EN ISO 11925-2:2020	Reaction to fire tests – Ignitability of products subjected to direct impingement of flame – Part 2: Single-flame source test (ISO 11925-2:2020)

ANNEX A: MODIFIED BLOCK SHEAR STRENGTH TEST OF HYBRID GLUE-LINES

The modified block shear test method comprises the following steps:

A.1 Sampling

- Five beams with the largest cross-sectional width shall be produced.
- From each beam cross-sectional slabs shall be cut at two positions (distance from the end of the end-grain: at least 500 mm).
- At each position two slabs shall be taken directly one after another, the two adjoining slices are named “A” and “B”.
- From each cross-sectional slab a stick with a width of b_{stick} = 50 mm, a depth of h_{stick} = ca. 80 mm and a length of L_{stick} = 50 mm shall be cut (see Figure A.2.1). If the cross-sectional width of the hybrid glulam is larger than 120 mm, two sticks shall be cut from each cross-sectional slab.

A.2 Test Method

a) Sticks from slice “A”

- The hybrid glue-lines of the sticks of slabs “A” shall be tested in block shear test in accordance with EN 14080, Annex D, in “dry condition”, i.e., in condition with production moisture content.
- From the test results the mean block shear strength at dry conditions $f_{v,block,dry,mean}$ shall be determined.

b) Sticks from slice “B”

- The sticks of slabs “B” shall be treated by a cyclic boiling/drying treatment in accordance with EN 14374, Annex B, with additional subsequent re-drying to the initial moisture content (± 2%).
- After the treatment the hybrid glue-lines in the sticks of slabs “B” shall be tested by block shear test in accordance with EN 14080, Annex D.
- From the test results the mean block shear strength after treatment $f_{v,block,treated,mean}$ shall be determined.
- The relative block shear strength rel $f_{v,block}$ is the quotient of the mean block shear strength after cyclic boiling/drying treatment and the mean block shear strength at dry conditions and shall be calculated in accordance with rel $f_{v,block} = f_{v,block,treated,mean} / f_{v,block,dry,mean}$.

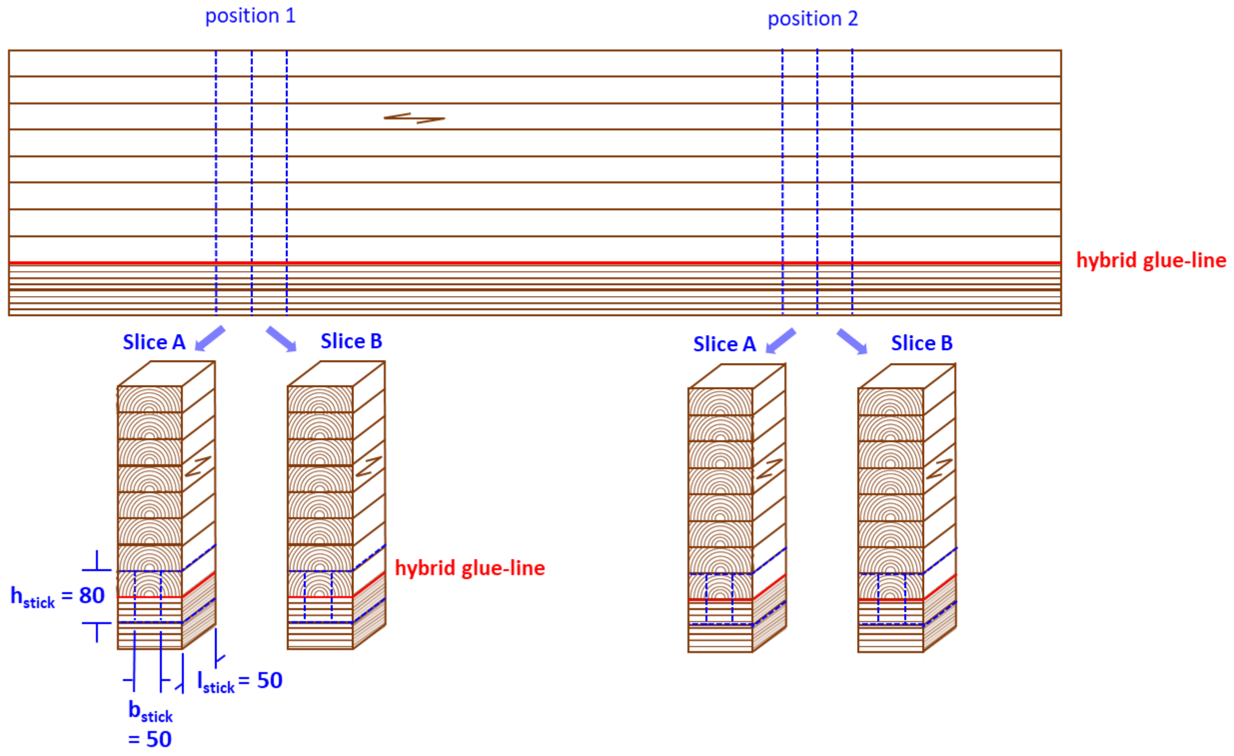

Figure A.2.1: Sampling scheme for the tests of a hybrid glue-line

ANNEX B: BASIC PRINCIPLES OF THE STRENGTH MODEL FOR HYBRID GLULAM

To simulate the bending strength of hybrid glulam based on the properties of solid timber laminations, LVL laminations and of finger-joints an apt calculation model can be used. The basic principles of the model lead to the following procedural steps:

- A two-dimensional Finite Element (FE) model of the hybrid glulam beam shall be used.
- The loading conditions of a 4-point bending test in accordance with EN 408 shall be simulated.
- In the centre (lengthwise) of the beam, i.e., in the zone of constant bending moment, a nonlinear section shall be located.
- In the compression zone of the non-linear section a tri-linear material law shall be employed: linear elastic, hardening and softening. The material law refers to empiric compression behaviour of solid timber glulam at compressive loading parallel to the grain.

  The nonlinear strain in the compression zone shall be limited to 1 %.
- In the tensile zone the material behaviour shall be assumed as brittle: the tensile strength of LVL laminations or the bending strength of the solid glulam part determines the failure in the tensile zone. The reduced strength (if applicable) of finger joints shall be simulated by reduced tensile strength of the LVL laminations.
- The load shall be applied by an imposed deformation at the loading points of the 4-point bending test set-up. The reaction force at the supports shall be recorded as a result of the simulations.
- The maximum load in the simulation run shall be assumed to be reached if either
  - the tensile strength criterion of solid glulam or LVL in the tensile zone is reached or
  - the load (= reaction force at the supports) starts to decrease at increasing imposed deformation
- The maximum moment related to the cross-section of the hybrid beam shall be given as the effective bending strength.

If it is intended to use the beams in service class 2 in accordance with EN 1995-1-1, the impact of these environmental conditions on the strength and stiffness properties shall be considered accordingly by reduction of the solid glulam compressive strength by a factor in accordance with EN 384, clause 5.4.2 (equation (1)).

ANNEX C: ASSESSMENT OF STRENGTH AND STIFFNESS PARAMETERS OF HYBRID GLULAM IN ACCORDANCE WITH THE PRINCIPLES OF THE ELASTIC COMPOSITE BEAM THEORY

C.1 General

In this Annex the approach when determining some strength and stiffness parameters of hybrid glulam in accordance with the elastic composite beam theory is given.

Input parameters

LVL laminations (top and/or bottom): $E_{t,0,l,LVL} = E_{0,1}$ $E_{90,edge,l,LVL} = E_{edge,90,1}$ $E_{90,flat,l,LVL} = E_{90,flat,1}$

depth = h_{LVL}, width = B

Solid timber glulam: $E_{0,g,mean} = E_{0,2}$ $E_{90,g,mean} = E_{90,2}$

depth = h_{g}, width = B

Depth of the hybrid glulam (symmetrical lay-up): H = $2h_{\mathrm{LVL}} + h_{\mathrm{g}}$

Depth of hybrid glulam (asymmetrical lay-up): H = $h_{LVL} + h_g$

Centroid: $y_{top} = y_{bot} = \frac{H}{2}$ (for symmetrical lay-up only)

Required strength and stiffness parameters are given in the respective clauses in section 2.

C.2 Bending strength of symmetrical hybrid glulam – Flatwise bending of laminations

Second moments of inertia

LVL laminations (considering top and bottom laminations): $2I_1 = \frac{B\left(H^3 - h_{\mathrm{g}}^3\right)}{12}$

Solid timber glulam: $I_2 = \frac{Bh_{\mathrm{Gg}}^3}{12}$

Determination of the decisive strength

a) **Case 1 – Determination of the stress at the bottom of the LVL laminations f_1^***

$$\sigma_1 = \frac{M\,\frac{H}{2}\,E_{0,1}}{2E_{0,1}I_1 + E_{0,2}I_2} \leq f_{m,l,flat,LVL,k}$$

$$W_1 = \frac{2E_{0,1}I_1 + E_{0,2}I_2}{\frac{H}{2}\,E_{0,1}}$$

$$M_{max,1} = f_{m,l,flat,LVL,k} \cdot W_1 = f_{m,l,flat,LVL,k}\,\frac{2E_{0,1}I_1 + E_{0,2}I_2}{\frac{H}{2}\,E_{0,1}}$$

$$f_1^* = \frac{M_{max,1}}{W_{ideal}} = \frac{f_{m,l,flat,LVL,k}W_1}{B\,\cdot\,H^2/6} = \left(f_{m,l,flat,LVL,k}\,\frac{2E_{0,1}I_1 + E_{0,2}I_2}{\frac{H}{2}\,E_{0,1}}\right)\Big/(B\,\cdot\,H^2/6)$$

b) **Case 2 - Stress in the glue line between solid timber glulam and LVL laminations f_2^***

$$\sigma_2 = \frac{M\left(\frac{H}{2} - h_{LVL}\right)E_{0,2}}{2E_{0,1}I_1 + E_{0,2}I_2} \leq f_{m,g,k}$$

$$W_2 = \frac{2E_{0,1}I_1 + E_{0,2}I_2}{\left(\frac{H}{2} - h_{LVL}\right)E_{0,2}}$$

$$M_{max,2} = f_{m,g,k} \cdot W_2 = f_{m,g,k} \frac{2E_{0,1}I_1 + E_{0,2}I_2}{\left(\frac{H}{2} - h_{LVL}\right)E_{0,2}}$$

$$f_2^* = \frac{M_{max,2}}{W_{ideal}} = \frac{f_{m,g,k}.W_2}{B \cdot H^2/6} = \left(f_{m,g,k} \frac{2E_{0,1}I_1 + E_{0,2}I_2}{\left(\frac{H}{2} - h_{LVL}\right)E_{0,2}}\right) \Big/ (B \cdot H^2/6)$$

c) Case 3 - Stress in the centroid of the LVL laminations f_3^*

$$\sigma_{m,1} = \frac{M\left(\frac{H}{2} - \frac{h_{LVL}}{2}\right)E_{0,1}}{2E_{0,1}I_1 + E_{0,2}I_2} \leq f_{t,0,l,LVL,k}$$

$$W_3 = \frac{2E_{0,1}I_1 + E_{0,2}I_2}{\left(\frac{H}{2} - \frac{h_{LVL}}{2}\right)E_{0,1}}$$

$$M_{max,m,1} = f_{t,0,l,LVL,k} \cdot W_3 = f_{t,0,l,LVL,k} \frac{2E_{0,1}I_1 + E_{0,2}I_2}{\left(\frac{H}{2} - \frac{h_{LVL}}{2}\right)E_{0,1}}$$

$$f_3^* = \frac{M_{max,3}}{W_{ideal}} = \frac{f_{t,0,l,LVL,k} \cdot W_3}{B \cdot H^2/6} = \left(f_{t,0,l,LVL,k} \frac{2E_{0,1}I_1 + E_{0,2}I_2}{\left(\frac{H}{2} - \frac{h_{LVL}}{2}\right)E_{0,1}}\right) \Big/ (B \cdot H^2/6)$$

d) Bending strength of the symmetrical hybrid glulam

$$f_{m,flat,k} = \min\left(f_1^*; f_2^*; f_3^*\right)$$

C.3 Bending strength parallel to the grain of hybrid glulam – Edgewise bending of laminations

$$f_{m,edge,k} = \min\left(f^*_{m,edge,l,LVL,k}, f^*_{m,g,k}\right)$$

$$f^*_{m,edge,l,LVL,k} = \frac{k_{j,LVL} \cdot f_{m,edge,l,LVL,k} \cdot E_{0,tot}}{E_{0,1}}$$

$$f^*_{m,g,k} = \frac{f_{m,g,k} \cdot E_{0,tot}}{E_{0,2}}$$

For symmetrical lay-up:

$$E_{0,tot} = E_{0,1} \cdot \frac{2 \cdot h_{LVL}}{H} + E_{0,2} \cdot \frac{h_g}{H}$$

For asymmetrical lay-up: $E_{0,tot} = E_{0,1} \cdot \frac{h_{LVL}}{H} + E_{0,2} \cdot \frac{h_g}{H}$

C.4 Tensile strength parallel to the grain of hybrid glulam

$$f_{t,0,k} = \min\left(f^*_{t,o,l,LVL,k}, f^*_{t,o,g,k}\right)$$

$$f^*_{t,0,l,LVL,k} = \frac{k_{j,LVL} \cdot f_{t,0,l,LVL,k} \cdot E_{0,tot}}{E_{0,1}}$$

$$f^*_{t,0,g,k} = \frac{f_{t,0,g,k} \cdot E_{0,tot}}{E_{0,2}}$$

For symmetrical lay-up: $E_{0,tot} = E_{0,1} \cdot \frac{2 \cdot h_{LVL}}{H} + E_{0,2} \cdot \frac{h_g}{H}$

For asymmetrical lay-up:

$$E_{0,tot} = E_{0,1} \cdot \frac{h_{LVL}}{H} + E_{0,2} \cdot \frac{h_g}{H}$$

C.5 Tensile strength perpendicular to the grain of hybrid glulam – Tension parallel to the glue-lines between the laminations

$$f_{t,90,edge,k} = \min\left(f^*_{t,9o,edge,l,LVL,k}, f^*_{t,9o,g,k}\right)$$

$$f^*_{t,90,edge,l,LVL,k} = \frac{f_{t,90,edge,l,LVL,k} \cdot E_{90,edge,tot}}{E_{90,edge,1}}$$

$$f^*_{t,90,g,k} = \frac{f_{t,90,g,k} \cdot E_{90,edge,tot}}{E_{90,2}}$$

For symmetrical lay-up:

$$E_{90,edge,tot} = E_{90,edge,1} \cdot \frac{2 \cdot h_{LVL}}{H} + E_{90,2} \cdot \frac{h_g}{H}$$

For asymmetrical lay-up

$$E_{90,edge,tot} = E_{90,edge,1} \cdot \frac{h_{LVL}}{H} + E_{90,2} \cdot \frac{h_g}{H}$$

C.6 Compression strength parallel to the grain of hybrid glulam

$$f_{c,0,k} = \min\left(f^*_{c,o,l,LVL,k}, f^*_{c,o,g,k}\right)$$

$$f^*_{c,0,l,LVL,k} = \frac{f_{c,0,l,LVL,k} \cdot E_{0,tot}}{E_{0,1}}$$

$$f^*_{c,0,g,k} = \frac{f_{c,0,g,k} \cdot E_{0,tot}}{E_{0,2}}$$

For symmetrical lay-up:

$$E_{0,tot} = E_{0,1} \cdot \frac{2 \cdot h_{LVL}}{H} + E_{0,2} \cdot \frac{h_g}{H}$$

For asymmetrical lay-up:

$$E_{0,tot} = E_{0,1} \cdot \frac{h_{LVL}}{H} + E_{0,2} \cdot \frac{h_g}{H}$$

C.7 Compression strength perpendicular to the grain of hybrid glulam – compression parallel to the glue-lines between the laminations

$$f_{c,90,edge,k} = \min\left(f^*_{c,9o,edge,l,LVL,k}, f^*_{c,9o,g,k}\right)$$

$$f^*_{c,90,edge,l,LVL,k} = \frac{f_{c,90,edge,l,LVL,k} \cdot E_{90,edge,tot}}{E_{90,edge,1}}$$

$$f^*_{c,90,g,k} = \frac{f_{c,90,g,k} \cdot E_{90,edge,tot}}{E_{90,2}}$$

For symmetrical lay-up:

$$E_{90,edge,tot} = E_{90,edge,1} \cdot \frac{2 \cdot h_{LVL}}{H} + E_{90,2} \cdot \frac{h_g}{H}$$

For asymmetrical lay-up:

$$E_{90,edge,tot} = E_{90,edge,1} \cdot \frac{h_{LVL}}{H} + E_{90,2} \cdot \frac{h_g}{H}$$

C.8 Modulus of elasticity parallel to the grain of hybrid glulam

For bending parallel to the grain with flatwise laminations the E-Modulus is

$$E_{m,0,mean} = E_{0,2} \cdot \frac{I_{tot}}{I_{ref}}$$

$$I_{tot} = 2 \cdot I_{LVL} + I_{GL}$$

$$I_{LVL} = B \cdot \frac{E_{0,1}}{E_{0,2}}\ h_{LVL} \cdot \left(\frac{h^2_{LVL}}{12} + \frac{\left(h_{LVL} + h_g\right)^2}{4}\right)$$

$$I_g = B \cdot \frac{h_g^3}{12}$$

$$I_{ref} = B \cdot \frac{H^3}{12}$$

C.9 Modulus of elasticity perpendicular to the grain of hybrid glulam

For loading perpendicular to the grain and parallel to glue-lines between the laminations the E-Modulus is

$$E_{90,edge,mean} = E_{90,edge,tot}$$

For symmetrical lay-up:

$$E_{90,edge,tot} = E_{90,edge,1} \cdot \frac{2 \cdot h_{LVL}}{H} + E_{90,2} \cdot \frac{h_g}{H}$$

For asymmetrical lay-up:

$$E_{90,edge,tot} = E_{90,edge,1} \cdot \frac{h_{LVL}}{H} + E_{90,2} \cdot \frac{h_g}{H}$$

For loading perpendicular to the grain and perpendicular to the glue-lines between the laminations the E-Modulus is

$E_{90,flat,mean} = E_{90,flat,tot}$

For symmetrical lay-up:

$$E_{90,flat,tot} = \frac{1}{\frac{2 \cdot h_{LVL}}{E_{90,flat,1} \cdot H} + \frac{h_g}{E_{90,2} \cdot H}}$$

For asymmetrical lay-up:

$$E_{90,flat,tot} = \frac{1}{\frac{h_{LVL}}{E_{90,flat,1} \cdot H} + \frac{h_g}{E_{90,2} \cdot H}}$$