TECHNICAL INFORMATION

KVH® (Structural Finger-Jointed Timber)

DUOBALKEN®, TRIOBALKEN® (Glued Solid Timber)

Revised version based on
DIN EN 1995-1-1:2010 (Eurocode 5-1-1)

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Contents

1 A high-precision material

Building with wood has a long tradition. People have used wood for constructing buildings for thousands of years. Buildings from earlier centuries which are still in use today provide testimony to the durability and residential quality of buildings constructed of wood.

Better than required by the standards
Residential buildings have to meet high standards in terms of safety and comfort. The building needs to provide good thermal protection in winter, protection against the heat in summer and sound insulation. The materials used are expected to be ecological and not be harmful to health, and exposed construction features are expected to have a lasting aesthetic appearance while requiring little care. In addition, modern timber construction requires dimensionally stable, dried solid timber products with precise dimensions. As the production technology in carpenter's shops has changed, with CNC trimming lines now commonplace, so materials with clearly defined specifications have become a requirement for smooth production processes.

The aforementioned requirements to be met by solid timber products are also reflected to some extent in tighter building regulations. The requirements set out in the agreement on KVH® structural finger-jointed timber are actually far more stringent than those contained in these building regulations, as explained below.

Technological advantages
The development of KVH® structural finger-jointed timber and Duobalken® and Triobalken® glued solid timber means that customers are now able to count on high-precision materials which are available ex stock in numerous dimensions and lengths in the form of kiln-dried, dimensionally stable and planed or exactly sized products.

KVH®, Duobalken® and Triobalken® are protected brand names.

Quality controls during the production of KVH® structural finger-jointed timber are performed according to the strict rules of the Überwachungsgemeinschaft KVH®, and producers are also monitored for compliance by independent testing organizations at regular intervals. The quality control stipulations of the monitoring group are set out in an agreement made with Holzbau Deutschland (Holzbau Deutschland - Bund Deutscher Zimmermeister [Federation of German Master Carpenters]).

KVH® structural finger-jointed timber
Solid timber for exposed and non-exposed applications which is strength graded either visually or mechanically and is kiln-dried, planed or exactly sized[1)] and comes with defined dimensional stability. As a general rule KVH® is finger-jointed. It is normally supplied in lengths of 13 m, but longer lengths are available on request. KVH® meets the building regulation requirements of DIN 1052: 2008, Annex I (for finger-jointed KVH®) and DIN EN 14081-1 in conjunction with DIN 20000-5 (for non-finger-jointed structural timber). What is more, compliance with the supplementary requirements relating to the agreement on structural finger-jointed timber is also monitored by internal and external controls and inspections.
[1)] *Exactly sized: Planed to size after drying, without any guarantee of smoothly planed out surfaces.*

Duobalken® and Triobalken® *(glued solid timber)*
Composite solid timber cross-section made of either two or three individual lengths of wood with identical cross-sections which are glued together. The lamellas are finger-jointed as a rule. Duobalken® and Triobalken® are normally supplied in lengths of 13 m, but longer lengths are available on request. Duobalken® and Triobalken® are manufactured in accordance with the general technical approval of the German building authorities (product approval number Z 9.1-440) as assessed by the Deutsche Institut für Bautechnik. Quality-related requirements over and above those of the general technical approval, such as requirements to be met by the surface, are set out in the agreement made with Holzbau Deutschland (Holzbau Deutschland - Bund Deutscher Zimmermeister). As is the case with KVH®, compliance with the supplementary requirements relating to quality is also monitored through internal and external controls and inspections by independent agencies.

Sustainability

Wood has the advantage over other construction materials in ecological terms. In addition to its unique selling point of being the only renewable structural construction material to be available in large quantities, the fact that it is also associated with short transportation distances, is easy to work, and is produced with no waste are just some of the reasons why the production of timber building components requires less energy input than building components made of other materials which are comparable in functional terms.

Further details are provided in an environmental product declaration due to be issued in the near future and which will be contained on the www.kvh.de homepage.

Precision prefabrication and energy-efficient construction

The high level of dimensional stability offered by KVH®, Duobalken® and Triobalken® (see Table 3.1 and 3.2) is an important prerequisite for efficient mechanical woodworking in firms specializing in timber construction. Without these types of timber products it would not be possible to use cost-saving CNC machines and achieve a high degree of prefabrication.

Given the high standards that modern buildings have to meet in terms of energy requirements, the shells of buildings have to be permanently airtight. The building components must be finished to an exact fit and the usual moisture-related changes in the shape of the wood must not compromise the airtightness. High-tech timber products such as KVH®, Duobalken® and Triobalken® make it possible to achieve airtight timber buildings which are therefore energy-efficient and have a high standard of heat insulation.

2 Production and technical characteristics

For the production of KVH®, Duobalken® and Triobalken®, softwood, in most cases spruce, is used for primary conversion to rough beams on state-of-the-art chipper and circular saw lines. The side-products of sawing such as bark, chopped wood and chips are used in full for the generation of energy and the production of paper or derived timber products.

After drying in fully automated computer-controlled kilns, the timber is strength graded. Growth-related flaws which could reduce the strength of the product are cut out of the beam. The individual cross-sections produced in this way are joined together by their ends with finger joints to form what can theoretically be endless beams.

After the finger jointing (subject to length this can be dispensed with on request) the pieces of timber are cross cut to length and precisely planed or leveled.

For Duobalken® and Triobalken® this is followed by the gluing together of the individual lamellas to form an overall cross-section and then further planing. The products are cured and stored in air conditioned storage buildings to ensure that the beams are dry and dimensionally stable before they are delivered. Every stage of production is subject to permanent quality controls (internal controls and inspections and external controls and inspections by independent agencies).

Table 2.1 - Wood species, strength classes and calculated values of the building physics characteristics

Technical characteristics	KVH®	Duobalken®/Triobalken®
Wood species	Spruce. On request also fir, pine, larch, Douglas fir	
Strength class / grading class compliant with DIN 4074-1	C24 / S 10 TS[1)] or S10 K[2)] TS	
Moisture content u_m	15 % ± 3 %	≤ 15 %
Calculated swelling and shrinkage ratio	0.24% per 1% change of wood moisture content	
Building materials class in accordance with DIN EN 13501-1 and/or DIN 4102	D-s2, d0 or B2 (with normal flammability)	
Calculated thermal conductivity λ	0.13 W / (mK)	
Water vapor diffusion resistance factor μ	40	

1) The code "TS" stands for dry-graded, i.e. for grading performed at a moisture content of u_m ≤ 20 %

2) The code "K" identifies a board which is graded like square-sawn timber or a plank which is graded like square-sawn timber.

3) In practice, the mean moisture content is decisive for assessing the moisture content. u_m is the arithmetic mean of the measurements taken per piece of timber with electrode insertion depths of 5 mm (surface moisture content), 1/2 • timber thickness (core moisture content) and 1/3 • timber thickness (mean moisture content).

3 Requirements and fields of application

An overview of the product regulations applicable at the time of printing is contained in Table 5.3.

On top of the aforementioned building regulation requirements. KVH® structural finger-jointed timber also has to meet the additional requirements of the agreement on structural finger-jointed timber (see Table 3.1).

KVH® structural finger-jointed timber

IDIN EN 1995-1-1:2010. section 3.2 "Solid timber", sets out a requirement on the one hand for strength grading in accordance with DIN EN 14081-1, while on the other hand requiring finger joints in accordance with DIN EN 385. Finger-jointed structural timber, such as KVH® for example, is as a general rule permitted to be used for fields of application in which the use of solid timber is permitted. For finger-jointed structural timber there is the additional restriction that it is only permitted to be used in Service Classes 1 and 2.

The aforementioned DIN EN 385 standard is not a harmonized European product standard for structural finger-jointed timber. Not included in the standard, for example, are comprehensive requirements for quality controls and marking. Until the European product standard for structural finger-jointed timber, known as DIN EN 15497 and currently in preparation, comes into force, the current national product standard, DIN 1052:2008, Annex I, will continue to apply. This is still the case even after 1 July 2012, the date from which Eurocode 5-1-1 has replaced DIN 1052:2008 as the applicable dimensioning standard in most of the German federal states! At the time of printing of this brochure it is not anticipated that the aforementioned future European product standard DIN EN 15497 will become applicable before 2013.

REMARKS: To become applicable in Germany in the future. a German version of DIN EN 15497 has to be issued and published in German Bauregelliste B (Construction Products List B) from the DIBt. Moreover, it also requires a concomitant application standard in the DIN 20000-x series of standards to which the LTB (Listen der technischen Baubestimmungen [German Lists of Acknowledged Technical Rules for Works]) can refer.

For non-finger-jointed KVH® the European product standard DIN EN 14081-1, in conjunction with the corresponding application standard DIN 20000-5, can already be applied today. Application standard DIN 20000-5 specifies which of the technical classes contained in DIN 14081-1 are permitted to be applied in Germany.

The use of KVH® structural finger-jointed timber in accordance with German standard DIN 1052:2008 in other European countries needs to be clarified with the owner-builders and the relevant supervisory authorities in good time.

KVH®

Duobalken®

Triobalken®

Duobalken® / Triobalken®

Glued solid timber is not covered in EN 1995-1-1 because so far it has not counted as a construction product subject to European definition. This gap has been closed with the supplement in the National Annex DIN EN 1995-1-1/NA, section NCI NA.3.8 "Glued solid timber", with the following definition:

1. Glued solid timber requires certification of suitability for use under the building regulations. Certification of suitability for use under the building regulations for Duobalken® and Triobalken® has been obtained in the form of general technical approval of the German building authorities (product approval number Z-9.1-440) issued by the Deutsche Institut für Bautechnik (DIBt).

2. Glued solid timber is only permitted to be used in Service Classes 1 and 2.

3. Unless stipulated otherwise in the respective general technical approval of the German building authorities, the applicable strength, rigidity and raw density characteristics shall be those of the individual lamellas.

4. Unless stipulated otherwise in the respective general technical approval of the German building authorities, glued solid timber is to be dimensioned in the same way as solid timber.

On top of the building regulation requirements in accordance with general technical approval Z-9.1-440. Duobalken® and Triobalken® also have to meet the additional requirements of the agreement on Duobalken® /Triobalken® (see Table 3.1).

In future. glued solid timber is to be regulated by the harmonized European product standard for cross laminated timber and glued solid timber, DIN EN 14080. At the time of printing of this brochure it is not anticipated that DIN EN 14080: 2012 will become applicable before 2013.

REMARKS: To become applicable in Germany in the future, a German version of DIN EN 14080 has to be issued and published in German Bauregelliste B (Construction Products List B) from the DIBt. Moreover, it also requires a concomitant application standard in the DIN 20000-x series of standards to which the LTB (Listen der technischen Baubestimmungen [German Lists of Acknowledged Technical Rules for Works]) can make reference.

The use of Duobalken® or Triobalken® glued solid timber in accordance with German product approval in other European countries needs to be clarified with the owner-builders and the relevant supervisory authorities in good time.

An overview of the product regulations applicable at the time of printing is contained in Table 5.3.

REMARKS: At the time of printing of this brochure the new DIN 68800 standard has not yet been added to the Listen der technischen Baubestimmungen (German Lists of Acknowledged Technical Rules for Works) [LTB]: Until its addition, as anticipated in the near future, the older and technically outdated version of DIN 68800 will continue to apply in formal terms. However, the highest building authorities of the German federal states have no objection to DIN 68800- 1:2011-10 and DIN 68800-2:2012-02 being applied in advance. Until the new DIN 68800 standard is actually included in the LTB, agreement to its application should be sought in advance from the owner-builders and building regulation authorities. For the up-to-date status of the LTB, please refer to the homepage of the Deutsche Institut für Bautechnik (DIBt) (http://dibt.de/de/aktuelles_technische_baubestimmungen.html).

Fields of application for KVH®

Finger-jointed KVH® is permitted to be used in Service Classes 1 and 2 in accordance with DIN EN 1995-1-1 (see Table 3.3). KVH® without finger joints is also permitted to be used in Service Class 3. KVH® structural finger-jointed timber is kiln-dried. The requirements of DIN 68800-1: 2011-10, 3.20, to be met by kiln-drying (over a minimum of 48 hours in a process-controlled technical plant at a temperature of a least 55° C to 20 %) are met.

Timber products with a permanent moisture content of below 20% when installed in a building can be assigned to Use Class (GK) 0 or GK 1 in accordance with DIN 68800 and are not at risk from wood-destroying fungi.

The risk of structural damage from wood-destroying insects can, on the basis of DIN 68800-1: 2011-10, 5.2.1, be completely ruled out for Use Class 0.

The risk of structural damage from wood-destroying insects can, on the basis of DIN 68800-1: 2011-10, 8.2, be prevented by the use of kiln-dried timber products, such as KVH® structural finger-jointed timber, for Use Class 1. The conditions for Use Class GK 2 are not to be expected in practice according to DIN 68800-2, such that building components which are roofed over can generally be assumed to have a moisture content of u ≤ 20% and that the conditions of Use Class GK 0 or 1 can therefore be assumed.

In Use Class GK 3.1 permanent levels of moisture content of u >20 % are to be expected. Finger-jointed KVH® is not permitted to be used at this level of moisture content according to DIN 1052 2008 [3] and DIN EN 1995-1-1/NA [4]. The use of non-finger-jointed KVH® made of naturally durable Douglas fir or larch, on the other hand, is possible.

Preservative treatment must not be used unless necessary.

According to DIN 68800-1: 2011, 8.1.3, "constructions with special structural protection of wood in accordance with DIN 68800-2 … should have preference over constructions requiring preservative treatment in accordance with DIN 68800-3." The same section also states: "In rooms intended to be used as occupiable rooms, no use is to be made of preservative treatment or of building components treated with preservative treatment. For workplaces and similar this only applies insofar as it is technically possible."

The latest general technical approvals of the German building authorities for wood preservatives take account of the requirements of DIN 68800-1: 2011 and prohibit the use of wood preservatives in occupiable rooms and their ancillary rooms and the avoidable large-scale use in other indoor areas.

In addition, the latest product approvals only permit the product to be used if it is still necessary for the protection of the wood after all alternatives for the structural protection of the wood have been exhausted. **Table 3.3 shows, however, that KVH® is available which is suitable for up to Use Class GK 3.1 and which makes the use of preservative treatment superfluous.**

Table 3.1 - Requirements to be met by KVH® structural timber in accordance with the inspection regulations and the agreement between the Bund Deutscher Zimmermeister (BDZ) and Überwachungsgemeinschaft Konstruktionsvollholz e.V.

Grading criterion	Requirements to be met by KVH®		Remarks
	Exposed areas (KVH®-Si)	Non-exposed areas Bereich (KVH®-NSi)	
Grading class compliant with DIN 4074-1 1)	Min. S10TS or S10K2) TS; C24 in accordance with DIN EN 338		The decisive strength, rigidity and raw density characteristics of relevance for load-bearing capacity are derived for the dimensioning according to EC 5 from DIN EN 338, Table 1 in conjunction with DIN 20000-5 and EN 1995-1-1/NA. The elasto-mechanical characteristics are listed in Table 5.5 of this publication.
Moisture content	u_m: 15% ± 3%		The specified moisture content is a precondition for dispensing for the most part with preservative treatment and can also be the precondition for finger joint assembly.
Type of cutting	Split-heart; free-of-heart on request.	Split-heart	**Split-heart:** Given that the pith does not always automatically run through the middle of the log, split-heart is defined as follows: For a log with an ideal growth form, the pith would be cut through in two-strand cutting. **Free-of-heart**: Heart plank with d ≥ 40 mm is cut away
Wane	Not permitted	≤ 10% of the smaller cross-section side	
Dimensional stability of the cross-section	DIN EN 336 Dimensional stability class 2: b ≤ 100 mm: ± 1 mm b > 100 mm: ± 1.5 mm		The dimensional stability for the longitudinal dimensions must be agreed between the customer and supplier.
Knot condition	Loose knots and dead knots not permitted. Occasional faulty knots or parts of knots up to max. 20 mm in diameter are permitted	DIN 4074-1 Grading class S10	Replacement with natural wood dowels is permitted.
Knot diameter ratio	S 10: A ≤ 2/5 not exceeding 70 mm		Knot diameter ratio A is determined in accordance with DIN 4074-1. The following applies for mechanical grading:: • Knot sizes are not taken into consideration for KVH®-NSi • A ≤ 2/5 applies for KVH® -Si
Ingrown bark	Not permitted	DIN 4074-1	
Cracks, radial cracks caused by shrinking (shrinkage shakes)	Width of the crack b must be ≤ 3% of the respective cross-section width	DIN 4074-1	For Si the requirements are higher than those applicable to grading class S10 in accordance with DIN 4074-1.
Pitch pockets	Width b ≤ 5 mm	-	Additional criterion
Discoloration	Not permitted	DIN 4074-1	For Si the requirements are higher than those applicable to grading class S10 in accordance with DIN 4074-1.
Insect attack	Not permitted	DIN 4074-1	For Si the requirements are higher than those applicable to grading class S10 in accordance with DIN 4074-1
Twisting	-	-	The permissible extent of twisting is not specified in further detail because no unacceptable twisting is to be expected if all the other criteria are complied with.
Longitudinal warping	≤ 8 mm/2 m for split-heart cutting ≤ 4 mm/2 m for heart-free cutting	≤ 8 mm/2 m for split-heart cutting	In comparison: In accordance with DIN 4074-1 S10: ≤ 8 mm/2 m
Finishing of the ends	Trimmed perpendicular		
Surface quality	Planed and chamfered	Leveled and chamfered	
Finger-jointing	DIN EN 385		

1) The German national grading standard DIN 4074-1 complies with the requirements of EN 14081-1, which is referred to by EN 1995-1-1 as a decisive grading standard for solid timber. Using DIN EN 1912 it is possible to assign the national grading classes for square-sawn timber and for boards and planks used as square-sawn timber to the European strength classes from DIN EN 338.

2) The code "K" identifies a board which is graded like square-sawn timber or a plank which is graded like square-sawn timber.

Fields of application for Duobalken® and Triobalken®

Service Class 1 and 2 in accordance with DIN EN 1995-1-1 (see Table 3.3). In all respects the information relating to KVH® applies.

Table 3.2 - Requirements to be met by Duobalken® and Triobalken® in accordance with the general technical approval (abZ) of the DIBt Z-9.1-4401) dated 30/01/2009

Grading criterion	Requirements to be met by Duobalken® and Triobalken®		Remarks
	Exposed areas	Non-exposed areas	
Technical standard	abZ Nr. Z-9.1-440		
Grading class compliant with DIN 4074-1[1)]	Min. S10 TS or S10K[2)] TS; C24 in accordance with DIN EN 338		The decisive strength, rigidity and raw density characteristics of relevance for load-bearing capacity are derived from abZ Z 9.1-440. They are listed in Table 5.5 of this publication.
Moisture content u_m	Max. 15%		Precondition for gluing
Dimensional stability of the cross-section	DIN EN 336, Dimensional stability class 2 b ≤ 10 cm ± 1.0 mm b > 10 cm ± 1.5 mm		The dimension tolerances for length must be agreed between the customer and supplier.
Twisting	≤ 4 mm/2 m		In comparison: DIN 4074-1:S 10: ≤ 8 mm/2 m
Longitudinal warping	≤ 4 mm/2 m		In comparison: DIN 4074-1:S 10: ≤ 8 mm/2 m
Surface quality	Planed and cham-fered	Leveled and cham-fered	The right-hand sides (sides adjacent to the heart) must face outwards
Finishing of the ends	Trimmed perpendicular		
Gluing together of the timber	in accordance with abZ Z-9.1-440		Adhesive type I according to DIN EN 301 Use characteristics according to DIN 68141
Finger-jointing	DIN EN 385		

1) The German grading standard DIN 4074-1 complies with the requirements of EN 14081-1, which is referred to by EN 1995-1-1 as a decisive grading standard for solid timber. Using DIN EN 1912 it is possible to assign the national grading classes for square-sawn timber and for boards and planks used as square-sawn timber to the European strength classes from DIN EN 338.

2) The code "K" identifies a board which is graded like square-sawn timber or a plank which is graded like square-sawn timber.

Table 3.3 - Service and use classes

Service classes in accordance with DIN EN 1995-1-1[1]	Use class in accordance with DIN 68800-1: 2011	Conditions of use	Use of KVH®. Duobalken®/Triobalken®
NKL 1 – Dry areas u_m ≤ 12 % (5 bis 15 %) or	GK 0	• permanently closed skin • moisture content permanently u_m ≤ 20% • the risk of structural damage from insects can, on the basis of DIN 68800-1: 2011, 5.2.1, be ruled out.	KVH® or Duobalken®/Triobalken® made of softwood
NKL 2 – Areas susceptible to high humidity u_m ≤ 20 % (10 bis 20 %)	GK 1	• open but roofed-over areas of installation (no direct exposure to the weather) • moisture content permanently u_m ≤ 20%	
	GK 2	• roofed over • not exposed to the weather • occasionally but not permanently u_m > 20%	These conditions are not to be expected in practice according to DIN 68800-2. If components are assigned to GK2 nevertheless, the use of KVH® or Duobalken® / Triobalken® made from larch,pine or Douglas fir heartwood is possible.
NKL 3 – Outside areas u_m > 20 % (12 bis 24 %)	GK 3.1	• exposed to the weather or building with possible formation of condensation water • occasionally but not permanently u_m > 20%	KVH® without finger-jointing made from larch or Douglas fir
	GK 3.2 and higher	See DIN 68800-1: 2011	KVH® without finger-jointing but with chemical preservative treatment (preservative with technical approval and the mandatory test certificates)

[1] The values in brackets indicate the anticipated moisture levels of components in air currents according to DIN EN 1995-1-1/NA..

4 Product range and preferred cross-sections

KVH®, Duobalken® and Triobalken® made of the wood species spruce are available for immediate delivery from stock in a wide range of preferred cross-sections. The wood species pine and fir and the more durable larch and Douglas fir are available on request.

Cost savings with preferred cross-sections

Preferred cross-sections in the construction dimensions typically used in timber construction enable major cost savings to be made. For firms specializing in timber construction the stocks of timber held by timber wholesalers save them the need to maintain extensive stocks themselves, giving them planning freedom without tying down operating capital. Industrial production systems enable manufacturers to produce at low cost.

Table 4.1 - Preferred cross-sections (house building sector) for KVH® NSi made of spruce/fir

Width (mm) \ Height (mm)	100	120	140	160	180	200	220	240
60		■	■	■	■			
80		■	■	■	■	■	■	■
100	■	■	■	■	■	■	■	■
120		■	■	■	■	■	■	■
140			■	■	■	■	■	■

Timber also supplied cut to special dimensions as listed

The organization of production is so flexible that it is also possible to supply lengths cut to special building-specific dimensions "as listed". This means that dried and dimensionally stable timber can also be supplied where job order planning is the preferred option.

Dimensions

The maximum available cross-sectional dimensions of KVH® are limited by the kiln-drying and minimum split-heart cutting requirements. With maximum dimensions of approx. 14/26 cm, KVH® is capable of meeting most normal requirements, e.g. for ceiling beam cross-sections. For larger cross-sections or high requirements in terms of appearance, Duobalken® and Triobalken® are available, the cross-sectional dimensions of which are subject to the limits set by the approval by the German building authorities:

Duobalken® b/h ≤ 16/28 cm (2 x 8/28 cm)
Triobalken® b/h ≤ 24/28 cm (3 x 8/28 cm)
b/h ≤ 10/36 cm (3 x 10/12 cm)

Table 4.2 - Preferred cross-sections (house building sector) for Duobalken®/Triobalken® (NSi/Si) made of spruce/fir

Width (mm) \ Height (mm)	100	120	140	160	180	200	220	240
60	■	■	■	■	■	■	■	■
80	■	■	■	■ ●	■ ●	■ ●	■	■
100	■	■	■ ●	■ ●	■ ●	■ ●	■ ●	■ ●
120		■ ●		■ ●	■ ●	■ ●	■ ●	■ ●
140			■ ●	■ ●	■ ●	■ ●	■ ●	■ ●
160				■ ●		■ ●	■ ●	■ ●
180					■ ●	■ ●	■ ●	■ ●
200						■ ●	■ ●	■ ●
240								■ ●

■ = *NSi non-exposed areas*
● = *Si exposed areas*

5 Dimensioning according to DIN EN 1995-1-1 (Eurocode 5-1-1)

5.1 Principles

General information on Eurocode 5: Design of timber structures — Part 1-1: General — Common rules and rules for buildings – The latest position in the development of the Eurocodes

The development of European dimensioning standards, or Eurocodes, started in the mid-1970s. These are intended to become applicable througthout Europe and therefore contribute to the opening up of the European construction market. In Germany the Eurocodes have been published as European standards in the DIN EN 1990 to 1999 series and replace national dimensioning standards and regulations (DIN standards) on a step-by-step basis.

The Eurocodes contain so-called national determined parameters (NDP). With these parameters, such as the partial safety factors for load and material parameters, the national building regulation authorities are able to specify the national safety level they specifically desire. The NDPs are specified in a National Annex (NA) to the respective Eurocode. National annexes are denoted in a German standard by a supplementary "/NA" accompanying the number of each standard. DIN EN 1995-1-1/NA, for example, is the National Annex to DIN EN 1995-1-1. The national annexes are permitted to contain rules and explanations to supplement the NPDs and the Eurocode as long as they do not contradict them (non-contradictory complementary information [NCI]). There are numerous NCI in relation to Eurocode 5-1-1 and 5-2.

Eurocode 5 was developed for timber construction and at the time of printing of this brochure it was available in full along with each corresponding national annex:

- DIN EN 1995-1-1: 2010-12 - Eurocode 5: Design of timber structures — Part 1-1: General – Common rules and rules for buildings
- DIN EN 1995-1-1/NA - National Annex - National determined parameters – Eurocode 5: Design of timber structures — Part 1-1: General – Common rules and rules for buildings
- DIN EN 1995-1-2: 2010-12 - Eurocode 5: Design of timber structures — Part 1-2: Common rules – Structural fire design
- DIN EN 1995-1-2/NA - National Annex - National determined parameters – Eurocode 5: Design of timber structures — Part 1-2: Common rules – Structural fire design
- DIN EN 1995-2: 2010-12 - Eurocode 5: Design of timber structures — Part 2: Bridges
- DIN EN 1995-2/NA - National Annex - National determined parameters – Eurocode 5: Design of timber structures — Part 2: Timber bridges

With effect from 1 July 2012 the application of Eurocode 5 is supposed to be binding; from this date onwards the previous national standards DIN 1052, DIN 1074 and DIN 4102 (in part) are supposed to be deleted from the LTB.

The safety concept behind partial safety factors

As in DIN 1052:2008 before it, DIN EN 1995-1-1 is based on a semi-probabilistic safety concept involving partial safety factors. In the same way as with most other construction materials, with respect to timber construction Eurocode 5 also continues the policy of differentiating between the verifications for load-bearing safety and serviceability (deflection, vibration).

[1] *Dimensioning values indicated by index d (design)*

[2] *Characteristic values indicated by index k*

What has to be checked in relation to the verification of load-bearing capacity is that the dimensioning values for the strain (E_d) do not in any dimensioning situation exceed the dimensioning values for stress resistance (building component resistance R_d).

Verification:	$E_d \leq R_d$
Dimensioning value for strai:	$E_d = \gamma_G \cdot G_k + g_Q \cdot Q_k$
Dimensioning value for stress resistance:	$R_d = \frac{k_{mod} \cdot R_k}{\gamma_M}$

The dimensioning values are determined by multiplying the characteristic[2] action from permanent and variable loads (G_k or Q_k) by the partial safety factors γ_G or γ_Q. Similarly, the characteristic building component resistance R_k is reduced by a material partial safety factor γ_M.

In relation to the verifications of load-bearing capacity, factor k_{mod}, as a so-called modification factor, takes account of the particular material properties of the wood in dependency on predominant climatic conditions and the load duration. The climatic conditions are defined within the framework of the service classes; see Table 3.3 on page 9. Checks on serviceability must take into account the deformation factors k_{def} specified in each case, which take account of the variations in creep behavior in wood and derived timber products. The material partial safety factors γ_M, the modification factors k_{mod} and the deformation factors k_{def} are to be taken from DIN EN 1995-1-1/NA in the first instance. Values from DIN EN 1995-1-1 are only applicable if DIN EN 1995-1-1/NA does not specify any different values.

Table 5.1 – Factors γ_M, k_{mod} and k_{def}

	DIN EN 1995-1-1	DIN EN 1995-1-1/NA (Nat. Annex)
Partial safety factor γ_M	Table 2.3 does not apply!	Following applies: Table NA.2, Table NA.3 Addition of values for glued solid timber, cross laminated timber, solid wood board, plaster board, plaster fiber board, cement-bonded chipboard
Modification factors k_{mod}	Table 3.1	Following applies in addition: Table NA.4 Addition of values for glued solid timber, cross laminated timber, solid wood board, plaster board, plaster fiber board, cement-bonded chipboard
Deformation factors k_{def}	Table 3.2	Following applies in addition: Table NA.5 Addition of values for glued solid timber, cross laminated timber, solid wood board, plaster board, plaster fiber board, cement-bonded chipboard

Characteristic strength and rigidity properties and marking

For the dimensioning of non-finger-jointed solid timber, Eurocode 5-1-1 refers to the European harmonized product standard DIN EN 14081. For structural finger-jointed timber the requirement is also made that the finger joints must comply with DIN EN 385.

"Glued solid timber" (general term for Duobalken® and Triobalken®) as a product is not defined in DIN EN 1995-1-1. The required rules for dimensioning are therefore to be found in DIN EN 1995-1-1/NA. The European product rules and application standards for structural finger-jointed timber and non-finger-jointed solid timber and for glued solid timber referred to in Eurocode 5-1-1 are in part not yet available in the form of applicable standards; see section 3 for further details. Until all of the required standards are available, therefore, national product rules still apply on a transitional basis.

Therefore. at the time of printing of this document. the following regulations apply:

Table 5.2 – Product regulations in force on 01.06.2012

Product	Product regulation	Identification	Remarks
Non-finger-jointed sawn softwood	DIN 4074-1: 2003-08 or	"Ü" mark (inspection mark)	Only until 01.08.2012
	DIN EN 14081-1 with DIN 20000-5	CE mark	Can already be used
Finger-jointed solid timber	DIN 1052: 2008, Annex I	"Ü" mark (inspection mark)	DIN 1052: 2008 will remain the relevant product standard for some products after 01.07.2012, even though it will no longer be a valid dimensioning standard after this date.
Duobalken®, Triobalken® (glued solid timber))	abZ Z-9.1-440	"Ü" mark (inspection mark)	

1) Specification of permissible bending stress in accordance with the now obsolete DIN 1052:1988/1996, where the permissible σ_B = 10 N/mm².

2) Specification of characteristic flexural strength in accordance with DIN 1052:2008-12, where $f_{m,k}$ = 24 N/mm², which in contrast to the permissible σ_B does not contain a global safety factor.

Table 5.3 - Assignment of visual grading classes to European strength classes

Wood species (softwood)	Grading class in accordance with DIN 4074-1	Strength class
Spruce, fir, pine, larch, Douglas fir	S 10 TS or S 10K[1] TS	C 24

1) The code "K" identifies a board which is graded like square-sawn timber or a plank which is graded like square-sawn timber.

Table 5.4 - Strength and rigidity values in N/mm² and raw density characteristics in kg/m³ according to DIN EN 338 (for KVH®) and Z-9.1-440 (for Duobalken®/Triobalken®)

Characteristic	Explanation	Symbol	C24
Flexural strength		$f_{m.k}$	24
Tensile strength	Parallel to fiber Vertical to fiber	$f_{t.0.k}$ $f_{t.90.k}$	14 0.4
Compressive strength	Parallel to fiber Vertical to fiber	$f_{c.0.k}$ $f_{c.90.k}$	21 2.5
Shear strength (shear and torsion)		$f_{v.k}$	4[1]
Rolling shear strength		$f_{R.k}$	1
Modulus of elasticity	Mean value parallel to fiber	$E_{0.mean}$	11.000 for KVH® 11.600 for Duobalken®/Triobalken®
	5% quantile parallel to fiber	$E_{0.05}$	7.400 für KVH® 7.700 für Duobalken®/Triobalken®
	Mean value vertical to fiber	$E_{90.mean}$	370
Shear modulus		G_{mean}	690
Rolling shear modulus		$G_{R.mean}$	69
Density	5% quantile	ρ_k	350
	Mean value	ρ_{mean}	420
	For design loads according to DIN EN 1991-1-1	ρ	420

1) For verifications of shearing stresses due to lateral force, $f_{v,k}$ must be reduced by the factor k_{cr} according to DIN EN 1995-1-1 and DIN EN 1995-1-1/NA.

Results from the following dimensioning reference tables are shown in boxes with a green background

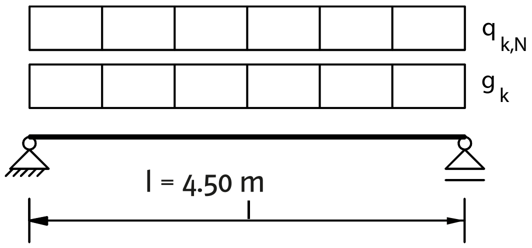
5.2 Example calculations for a timber beam ceiling

1. System. building component dimensions

Timber beam ceiling in the form of a simply supported beam

Spacing between beams: e = 62.5 cm

Material: KVH® structural timber, C 24



$q_{k,N}$ = Live load for habitable rooms and office floorspace in accordance with DIN1055-3, plus addition for partition walls of 0.8 kN/m²

2. Characteristic action

Permanent (dead loads) g_k = 1.75 kN/m²

Variable (live load including lightweight partition walls) $q_{k,N}$ = 2.80 kN/m²

Strength class C24 corresponds to grading class S 10 in accordance with DIN 4074-1; see table 5.4

Results from dimensioning reference table 6.2.2 – Ceiling beams, e = 62.5 cm, C24

For: l = 4.50 m	Result A (without vibration verification)	Result B (with vibration verification)
g_k = 1.75 kN/m²		
$q_{k,N}$ = 2.80 kN/m²	**KVH® C24: 10/24 cm**	**KVH® C24: 12/24 cm**
	Alternative:	Alternative:
	Duobalken® C24	**Duobalken® C24**

Cross-sectional values for

w/h = 8/24 cm

A = 192 cm²

W_y = 768 cm²

I_y = 9216 cm³

w/h = 10/24 cm

A = 240 cm²

W_y = 960 cm²

I_y = 11.520 cm³

Table 5.4 - Load combinations for verifications of load-bearing capacity

No.	Combination	Combination rule	Dimensioning value	Load duration class	k_{mod}
LK 1	g	$1.35 \cdot g_k$	$\Sigma q_d = 2.36$ kN/m²	Long	0.60
LK 2	g + p	$1.35 \cdot g_k + 1.5 \cdot q_k$	$\Sigma q_d = 6.56$ kN/m²	Medium	0.80

LK 2 is clearly decisive in this case, and this is used for further consideration.

Medium load duration in accordance with DIN EN 1995-1-1, Table 2.1 in conjunction with DIN EN 1995-1-1/NA, Table NA.1

k_{mod} = see below

Combination factors ψ in the case of variable loads in accordance with DIN 1055-100 and DIN EN 1990/NA for live loads falling under category A or B (habitable rooms, office floorspace)

$\psi_0 = 0.7$ / $\psi_1 = 0.5$ / $\psi_2 = 0.3$

3. Characteristic strength and rigidity properties C 24

Characteristic value for flexural strength $f_{m.k} = 24.0\ N/mm^2$

Characteristic value for shear strength $f_{v.k} = 2.0\ N/mm^2$

Modulus of elasticity parallel to fiber $E_{0.mean} = 11.000/11.600\ N/mm^2$

Values in accordance with DIN EN 338 in conjunction with DIN V 20000-5

Dimensioning values for stress resistance

Modification factor for solid timber $k_{mod} = 0.80$

Partial safety factor for wood $\gamma_M = 1.3$

Dimensioning value for flexural strength $f_{m.d} = 0.8 \cdot 24.0/ 1.3$ $f_{m.d} = 14.8\ N/mm^2$

Dimensioning value for shear strength $f_{v.d} = 0.8 \cdot 2.0 / 1.3$ $f_{v.d} = 1.23\ N/mm^2$

Partial safety factors in accordance with DIN EN 1995-1-1, Table 2.3 (γ_M) and Table 3.1 (kmod) in conjunction with DIN EN 1995-1-1/NA, Table NA.2, NA.3 and NA.4

$$R_d = \frac{k_{mod} \cdot R_k}{\gamma_M}$$

4. Stresses - Internal forces and moments and reactions at support

Internal forces and moments per beam (e = 62.5 cm)

Reference moment for LK 2:

$M_d = \Sigma q_d \cdot l^2 / 8 = 6.56 \cdot 4.50^2 / 8 \cdot 0.625$ $M_d = 10.38\ kNm$

Reference lateral force for LK 2:

$V_d = \Sigma q_d \cdot l / 2 = 6.56 \cdot 4.50 / 2 \cdot 0.625$ $V_d = 9.23\ kN$

Characteristic reactions at support for the decisive LK 2:

End support A and B: $A_{g.k} = B_{g.k} = 1.75 \cdot 4.50 / 2$ $A_{g.k} = 3.94\ kN/m$

$A_{q.k} = B_{q.k} = 2.80 \cdot 4.50 / 2$ $A_{q.k} = 6.30\ kN/m$

5. Preliminary estimate

Required section modulus:

$$W_{y,req} = M_d / f_{m,d} = 10.38 \cdot 10^3 / 14.8 \qquad W_{y,req} = 701\ cm^3$$

Results from dimensioning reference table 6.1 (Cross-sectional values):		
For $M_d = 10.38\ kNm$	**reqired w/h = 8/24 cm**	with $W_y = 768\ cm^3$

6. Verifications for the limit of load-bearing capacity state

Dimensioning value for bending stress:

$$\sigma_{m,y,d} = M_d / W_y = 10.38 / 768 \cdot 10^3 \qquad \sigma_{m,y,d} = 13.5\ N/mm^2$$

Verification:

$$\frac{\sigma_{m,y,d}}{f_{m,d}} = \frac{13.5}{14.8} = 0.91 < 1$$

Dimensioning value for shearing stress:

$$\tau_d = 1.5 \cdot V_d / A = 1.5 \cdot 9.23 / 192 \qquad \tau_d = 0.72\ N/mm^2$$

Verification:

$$\frac{\tau_d}{f_{v,d}} = \frac{0.72}{1.23} = 0.59 < 1$$

7. Verifications for the limit of serviceability state

In DIN EN 1995-1-1, section 2.2.3, it is recommended that the following two cases always be examined,

a) Limitation of initial deflection without time-dependent creep influences:

$$w_{inst} = w_{inst,G} + w_{inst,Q1} + \sum w_{inst,Q,i}\ (\text{with } i > 1) \leq l/300 - l/500$$

b) Limitation of final deflection with time-dependent creep influences:

$$w_{fin} = w_{fin,G} + w_{fin,Q1} + \sum w_{fin,Qi} \leq l/150 - l/300$$

Where there is a planned camber w_o, the following also needs to be examined:

c) Final deflection $w_{net,fin}$ less camber w_o:

$$w_{net,fin} = w_{fin} - w_o \leq l/250 - l/350$$

Section 7.2 (2) of DIN EN 1995-1-1 contains specifications for recommended deflection limitations. The specification of the actual limit depends primarily on which type of deformation is considered acceptable for technical reasons or reasons of appearance in each individual case. It can be assumed that the given maximum values for deflection have to be complied with in all cases.

Deflection stiffness for cross-section b/h = 8/24 cm

Calculation of deflection

$$E_{0,mean} \cdot I_y = 11.00 \cdot 92.16 \cdot 10^6 = 1.014 \cdot 10^{12}\ Nmm^2$$

Deformation factor k_{def} in accordance with DIN EN 1995-1-1, Table 3.2, in conjunction with DIN EN 1995-1-1/NA, Table NA.5 – for solid timber and glued solid timber: k_{def} (NKL 1)= 0.6

$$w_{inst,G} = \frac{5}{384} \cdot \frac{g_k \cdot l^4}{E \cdot I} = \frac{5}{384} \cdot \frac{(1.75 \cdot 0.625) \cdot 4500^4 \cdot 12}{11.000 \cdot 80 \cdot 240^3} = 5.8\ cm$$

$$w_{fin,G} = w_{inst,G}\,(1 + k_{def}) = 5.8 \cdot (1 + 0.6) = 9.3\ mm$$

$$w_{inst,Q} = \frac{5}{384} \cdot \frac{g_k \cdot l^4}{E \cdot I} = \frac{5}{384} \cdot \frac{(2.80 \cdot 0.625) \cdot 4500^4 \cdot 12}{11.000 \cdot 80 \cdot 240^3} = 9.2\ cm$$

$$w_{fin,G} = w_{inst,Q}\,(1 + k_{def}) = 9.2 \cdot (1 + 0.6) = 14.7\ mm$$

Proof of deflection

Case a) $w_{inst} = w_{inst,G} = 5.8 + 9.2 = 15\ mm$

for $w_{inst,max} = l/300 = 4500/300 = 15\ mm \rightarrow = w_{inst} \rightarrow$ o.k.

for $w_{inst,max} = l/500 = 4500/500 = 9\ mm \rightarrow > w_{inst} \rightarrow$ Enlargement of cross-section required

Case b) $w_{fin} = w_{fin,G} + \psi^2 * w_{fin,QG} = 9.3 + 0.3 * 14.7 = 13.7\ mm$

for $w_{fin,max} = l/150 = 4500/150 = 30\ mm \rightarrow > w_{fin} \rightarrow$ o.k.

for $w_{fin,max} = l/300 = 4500/300 = 15\ mm \rightarrow = w_{fin} \rightarrow$ o.k.

Case c) $w_{net,fin} = w_{fin} - w_o$ Not applicable, because there is no planned camber.

Vibration verification

DIN EN 1995-1-1 only covers vibrations for ceilings in residential buildings which have a natural frequency (first order fundamental component) of f1 > 8 Hz. All other cases require special investigation, but such investigations are not described in more detail. A simplified verification on the basis of a limitation of deflection, as was previously the case in DIN 1052, is not offered.

DIN EN 1995-1-1, section 7.3

The following conditions have to be met

$w / F \leq a$ und $v \leq b^{(f1 \cdot \zeta - 1)}$

Here

w is the greatest vertical initial deflection as a result of a concentrated vertical static point load F, acting at any point and determined with due consideration for the load distribution. It generally makes sense in this case to apply the so-called equivalent load for maintenance or repair of 1.0 KN as the basis for walking on the ceiling;

v is the unit pulse speed reaction

ζ the modal damping ratio (generally taken as 0.01))

The vibration behavior of a timber beam ceiling is dependent primarily on the rigidity of the load-bearing beams. The width of the ceiling is only taken into consideration with the contribution of the load-bearing ceiling planking and its capacity to transfer the vibrations vertically to the series of joists. For simplification a theoretical ceiling width of 1.0 m is assumed. The main characteristic vibration values can be applied to any ceiling desired widths. The following example is based on the use of tongued and grooved board planking of 24 mm in thickness.

Input values

$l_{ceiling} = l_{beam} = 4.5\ m$	$b_{ceiling} = 1.0\ m$	$b_{beam} = 8\ cm = 0.08\ m$
$h_{beam} = 24\ cm\ 0.24\ m$	$F = 1.0\ kN$	$m = 1.75\ kN/m^2 = 175\ kg/m^2$

Calculation of rigidity lengthwise $(EI)_l$ and crosswise $(EI)_b$ to the series of joists

The following applies in all cases $(EI)_l > (EI)_b$

$$(EI)_l = E_{beam} \cdot \frac{b_{beam} \cdot h_{beam}^3}{12 \cdot e_{beam}} = 11.000 \cdot 10^6 \cdot \frac{0.08 \cdot 0.24^3}{12 \cdot 0.625} = 1.622 \cdot 10^6\ Nm^2 / m$$

$$(EI)_b = E_{planking} \cdot \frac{b_{ceiling} \cdot d_{planking}^3}{12} = 11.000 \cdot 10^6 \cdot \frac{1.0 \cdot 0.024^3}{12} = 12.67 \cdot 10^3\ Nm^2 / m$$

A central parameter for vibration behavior is the natural frequency f_1 of the building component, which, for the further completion of the verification, must not be less than 8.0 Hz.

$$f_1 = \frac{\pi}{2 \cdot l^2} \cdot \sqrt{\frac{(EI)_l}{m}} = \frac{\pi}{2 \cdot 4.5^2} \cdot \frac{1.622 \cdot 10^6}{175} = 7.46\ Hz < f_{1,min} = 8.0\ Hz$$

The required natural frequency of 8.0 Hz cannot be achieved with the selected cross-section.

→ New beam cross-section selected: 10/24 cm

$$(EI)_l = E_{beam} \cdot \frac{b_{beam} \cdot h_{beam}^3}{12 \cdot e_{beam}} = 11.000 \cdot 10^6 \cdot \frac{0.10 \cdot 0.24^3}{12 \cdot 0.625} = 2.027 \cdot 10^6\ Nm^2 / m$$

$$f_1 = \frac{\pi}{2 \cdot 4.5^2} \cdot \sqrt{\frac{2.027 \cdot 10^6}{175}} = 8.23\ Hz > f_{1,min} = 8.0\ Hz$$

The speed reaction sets a minimum requirement to be met by the mass of the ceiling. The objective is to ensure that the vibration reaction in response to pulse-like actions (e.g. jumping, hopping) is minimized. For ceilings with articulated support on all sides, the following applies

$$v = \frac{4 \cdot (0.4 + 0.6 \cdot n_{40})}{m \cdot b \cdot l + 200}$$

where

$$n_{40} = \left\{\left[\left(\frac{40}{f_1}\right)^2 - 1\right] \cdot \left(\frac{b}{l}\right)^4 \cdot \frac{(EI)_l}{(EI)_b}\right\}^{0.25} = \left\{\left[\left(\frac{40}{8.23}\right)^2 - 1\right] \cdot \left(\frac{1.0}{4.5}\right)^4 \cdot \frac{2.027 \cdot 10^6}{12.67 \cdot 10^3}\right\}^{0.25} = 1.72$$

The outcome for the example ceiling is therefore

$$v = \frac{4 \cdot (0.4 + 0.6 \cdot 1.72)}{175 \cdot 1.0 \cdot 4.5 + 200} = 5.80 \cdot 10^{-3}$$

The value v is not permitted to exceed a certain limit. Fig 7.2 in DIN EN 1995-1-1 shows the relationship between the two reference parameters a and b. Value a in this case should not exceed 1.5, because otherwise the vibration behavior of a ceiling in such a case would not be particularly favorable.

On the basis of Fig. 7.2, DIN EN 1995-1-1, the following applies

a = 0 – 2 → better vibration behavior

and

a = 2 – 4 → poorer vibration behavior

It has to be verified that

$$\frac{w}{F} \leq a \leq 1.5 \ mm / kN$$

where the deflection w of the ceiling has to be calculated subject to a point load F. F is generally assumed here to be an equivalent load for maintenance or repair of 1.0 kN. In this example the resultant deflection is

$$w = \frac{Fl^3}{48\ EI} = \frac{1000 \cdot 4500^3 \cdot 12}{48 \cdot 11.000 \cdot 100 \cdot 240^3} = 1.5 \ mm$$

$$\rightarrow \quad \frac{w}{F} = \frac{1.5}{1.0} = 1.5 \ mm / kN$$

The limit for a is therefore only just achieved. According to Fig. 7.2 in DIN EN 1995-1-1 the value for reference parameters b = 100. This means that it can therefore be verified that

$$v \leq b^{(f1 \cdot \zeta - 1)} \rightarrow 5.80 \cdot 10^{-3} \leq 100^{(8.23 \cdot 0.01 - 1)} = 0.015 \rightarrow \text{o.k.}$$

It is apparent that the example structure is at the limits both in terms of natural frequency f1 and deflection due to excitation load F. Although vibration verification is achieved here on a borderline basis, the structure provides absolutely no room for manoeuver when it comes to fluctuations in practical execution on the building site. In cases such as this it is recommended that provision be made for a safety margin relative to the limits by selecting larger beam cross-sections.

Key

1 better behavior

2 poorer behavior

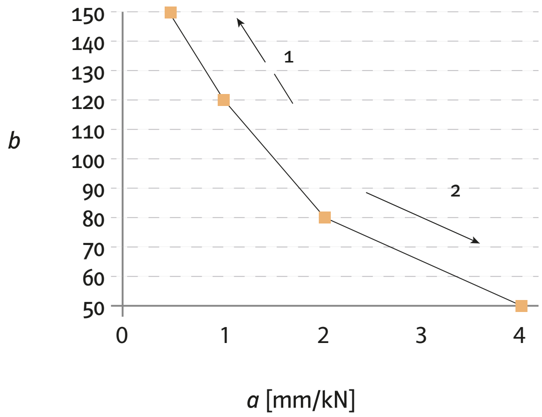


Fig. 7.2 – Recommended range and relationship between a and b

6 Dimensioning reference tables

6.1 General

DIN EN 1990

DIN EN 1990

Eurocode: Basis of structural design; German version of EN 1990:2002 + A1:2005 + A1:2005/AC:2010

DIN EN 1991-1-1

Eurocode 1: Actions on structures - Part 1-1: General actions – Densities, self-weight and imposed loads for buildings; German version EN 1991-1-1:2002 + AC:2009

DIN EN 1991-1-1

Eurocode 1: Actions on structures - Part 1-1: General actions – Densities, self-weight and imposed loads for buildings; German version EN 1991-1-1:2002 + AC:2009

DIN EN 1991-1-4

Eurocode 1: Actions on structures - Part 1-4: General actions – Wind actions; German version EN 1991-1-4:2005 + A1:2010 + AC:2010

The following dimensioning reference tables were drawn up for KVH®, Duobalken® and Triobalken® in strength class C24 (grading class S10 TS or S10 K TS in accordance with DIN 4074-1) using DIN EN 1995-1-1 (Eurocode 5) as the basis. As a general rule it is preferred cross-sections that are referred to (bold print). The design loads apply to typical cases in practice in accordance with DIN EN 1991. The decisive load combinations used for dimensioning purposes are based on DIN EN 1990.

The dimensioning reference tables are intended to provide an aid for day-to-day work. With the help of the tables it is possible to make quick preliminary estimates for the common situations encountered with residential and administrative buildings – they cannot be used as a substitute for a building-specific statical verification, however. The tables apply to applications covered by Service Classes 1 and 2 (SC 1 and 2) in accordance with DIN EN 1995-1-1, with a medium load duration.

Overview of dimensioning reference tables

6.2 Cross-sectional values and dimensioning values

Table 6.2 - Cross-sectional values and dimensioning values for stress resistance for preferred cross-sections in strength class C24 (grading class S10)[1)] for NKL 1 and 2 with medium load durations

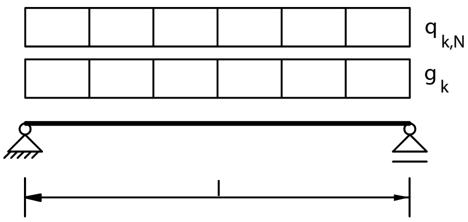
Solid timber cross-section b/d [cm]	Cross-sectional area A [cm²]	Section modulus Wy [cm³]	Moment of inertia I_y [cm⁴]	Stress resistance Flection[2)] $M_{R.d}$ [kNm]	Stress resistance Lateral force $V_{R.d}$ [kN]
6/10	60	100	500	1.48	4.92
6/12	72	144	864	2.13	5.91
6/14	84	196	1372	2.89	6.89
6/16	96	256	2048	3.78	7.88
6/18	108	324	2916	4.79	8.86
6/20	120	400	4000	5.91	9.85
6/22	132	484	5324	7.15	10.83
6/24	144	576	6912	8.51	11.82
8/10	80	133.33	666.67	1.97	6.56
8/12	96	192	1152	2.84	7.88
8/14	112	261.33	1829.33	3.86	9.19
8/16	128	341.33	2730.67	5.04	10.50
8/18	144	432	3888	6.38	11.82
8/20	160	533.33	5333.33	7.88	13.13
8/22	176	645.33	7098.67	9.53	14.44
8/24	192	768	9216	11.34	15.75
10/10	100	166.67	833.33	2.46	8.21
10/12	120	240	1440	3.54	9.85
10/14	140	326.67	2286.67	4.82	11.49
10/16	160	426.67	3413.33	6.30	13.13
10/18	180	540	4860	7.98	14.77
10/20	200	666.67	6666.67	9.85	16.41
10/22	220	806.67	8873.33	11.91	18.05
10//24	240	960	11520	14.18	19.69
12/12	144	288	1728	4.25	11.82
12/14	168	392	2744	5.79	13.78
12/16	192	512	4096	7.56	15.75
12/18	216	648	5832	9.57	17.72
12/20	240	800	8000	11.82	19.69
12/22	264	968	10648	14.30	21.66
12/24	288	1152	13824	17.01	23.63
14/14	196	457.33	3201.33	6.75	16.08
14/16	224	597.33	4778.67	8.82	18.38
14/18	252	756	6804	11.17	20.68
14/20	280	933.33	9333.33	13.78	22.97
14/22	308	1129.33	12422.67	16.68	25.27
14/24	336	1344	16128	19.85	27.57
16/16	256	682.67	5461.33	10.08	21.01
16/18	288	864	7776	12.76	23.63
16/20	320	1066.67	10666.67	15.75	26.26
16/22	352	1290.67	14197.33	19.06	28.88
16/24	384	1536	18432	22.69	31.51
18/18	324	972	8748	14.36	26.58
18/20	360	1200	12000	17.72	29.54
18/22	396	1452	15972	21.44	32.49
18/24	432	1728	20736	25.52	35.45
20/20	400	1333.33	13333.33	19.69	32.82
20/22	440	1613.33	17746.67	23.83	36.10
20/24	480	1920	23040	28.36	39.38
24/24	576	2304	27648	34.03	47.26

1) Dimensioning values determined for medium load duration in Service Classes 1 and 2:
Modification factor: k_{mod} = 0.8; partial safety factor for solid timber: γ_M = 1.3
2) Flection along the strong axis (y-y)

Cross-section values in bold print are preferred cross-sections for KVH®

6.3 Dimensioning of ceiling beams
Ceiling beam cross-sections for simply supported beams

Example system



<u>Notes on the development of the tables</u>

The values in column A relate to the bending stress and shearing stress verifications and the proof of deflection in accordance with EC 5. Here it should be noted that when determining the elastic deflection associated with the characteristic dimensioning situation in accordance with EN 1990, 6.5.3, the initial deflection element associated with the permanent load also has to be included. This means that the initial deflection is often decisive in many cases. Furthermore, less favorable values or a need for larger cross-sections can be the result in some cases compared to the deflection (without dead load element) determined on the basis of the previous DIN 1052.

The final deflection value is calculated as before with creep elements and the factor ψ_2 (DIN EN 1990, Table A.1.1) for variable loads.
In terms of limits, EC 5 only provides a limit range as a recommendation. In this case the limits which have applied to date from DIN 1052 are applied, because these are familiar to those in the field and are within the limit ranges given in EC 5. The following therefore continue to apply:

- $w_{inst} \leq l/300$
- $w_{fin} \leq l/200$

Limits which are exceeded by up to 3% in respect of elastic deflection in favor of cross-section dimensioning are acceptable in isolated instances. On the other hand, limits are not permitted to be exceeded for final deflection or for stress verifications, the objective being to ensure that load-bearing safety and serviceability are definitely guaranteed.

In column B the required cross-sections are determined with vibration verification in accordance with EC 5, 7.3.3, taken into consideration. EC 5 makes no provision for a simplified verification on the basis of the simplified limitation of deflection to be allowed.

Starting with the basic condition that the natural frequency f_1 is over 8.0 Hz, the two conditions $w/F \leq a$ and $v \leq b^{(f1+\zeta-1)}$ have to be determined via highly convoluted interrelationships. On the basis of Fig. 7.2 in EC 5 it is apparent that a > 1.5 tends to result in the achievement of more favorable vibration behavior. This condition is fulfilled if the deflection of the beam under a point load F = 1 kN is less than 1.5 mm. Any positive effects that planking may have in terms of load distribution are not taken into consideration here for the sake of a safety margin.

On the basis of Fig. 7.2 in EC 5 it is then possible to determine the second condition in association with the value b, the pulse velocity v, the damping ratio ζ (=0.01)) and the respective natural frequency.

The vibration verification in accordance with EC 5 does not actually involve the calculation of the vibration behavior of a beam but that of the ceiling as a whole taking into consideration the width of the ceiling. This is where the rigidity of the load distributing ceiling planking is taken into consideration. Timber planking of 24 mm in thickness was selected in this case. Variation calculations have shown that the influence of the planking on the vibration behavior is only of any relevance if it is relatively thick or rigid compared to the ceiling beams. Where timber planking or any other form of boarding has relatively low rigidity compared to the load-bearing system (ceiling beams), the ceiling width can be taken to be 1.0 m for simplification. As a result, the calculational influence of the ceiling width on the vibration behavior of the beam is more or less neutral. This means that the vibration verification for the ceiling beams can be provided independently of the ceiling width. For the purposes of compensatory safety, rather than taking a value of b=100 for value b, which would be the value which corresponds with the a-value of 1.5, a value of b=150 (maximum value on the scale in Fig. 7.2) was taken instead. It should be noted, however, that this condition is not decisive unless the planking has unrealistic dimensions of 8 – 10 mm.

Therefore, the decisive evaluation criteria for the vibration behavior here are taken to be the natural frequency (greater than 8.0 Hz in dependency on the mass of the ceiling) and the a-value as an indicator of deflection, and these are used as the basis for the dimensioning of the beams.

Ceiling beam cross-sections for simply supported beams

Tab. 6.3.1 - Ceiling beam cross-sections, C24 (S10), simply supported beams, e = 50 cm for NKL 1 and 2 with medium load durations

Simply supported beam, e = 50.0 cm C24 (S10)	**Beam cross-section b/h [cm][1)]** in dependency on span l and loads g_k and $q_{k.N}$											
Dead load[2)] g_k	1.75 kN/m²						2.50 kN/m²					
Live load[2)] $q_{k.N}$	2.00 kN/m²		2.80 kN/m²		3.00 kN/m²		2.00 kN/m²		2.80 kN/m²		3.00 kN/m²	
Dimensioning criterion[3)]	A	B	A	B	A	B	A	B	A	B	A	B
l = 3.00 m	**6/16** **8/14**	6/20 **8/18**	**6/18** **8/16**	6/20 **8/18**	**6/18** **8/16**	6/20 **8/18**	**6/18** **8/16**	6/20 **8/18**	**6/18** **8/16**	6/20 **8/18**	**6/18** **8/16**	6/20 **8/18**
l = 3.25 m	**6/18** **8/16**	6/22 **8/20**	**6/18** **8/16**	6/22 **8/20**	**6/18** **8/16**	6/22 8/20	**6/18** **8/16**	6/22 **8/20**	6/20 **8/18**	6/22 **8/20**	6/20 **8/18**	6/22 **8/20**
l = 3.50 m	**6/18** **8/16**	6/22 **8/20**	6/20 **8/18**	6/22 **8/20**	6/20 **8/18**	6/22 **8/20**	6/20 **8/18**	6/24 **8/20**	6/22 **8/20**	6/24 **8/22**	6/22 **8/20**	6/22 **8/20**
l = 3.75 m	6/20 **8/18**	6/24 **8/22**	6/22 **8/20**	6/24 **8/22**	6/22 **8/20**	6/24 **8/22**	6/22 **8/20**	6/24 **8/22**	6/24 **8/22**	6/26 **8/22**	6/22 **8/20**	6/24 **8/22**
l = 4.00 m	**8/28** **10/18**	**8/24** **10/22**	**8/20** **10/18**	**8/24** **10/22**	**8/20** **10/20**	**8/24** **10/22**	**8/20** **10/20**	**8/24** **10/22**	**8/24** **10/22**	**8/24** **10/22**	**8/22** **10/20**	**8/24** **10/22**
l = 4.25 m	**8/20** **10/18**	**8/24** **10/24**	**8/22** **10/20**	8/26 **10/24**	**8/22** **10/20**	8/26 **10/24**	**8/22** **10/20**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	**8/24** **10/22**	8/26 **10/24**
l = 4.50 m	**10/20** **12/18**	**10/24** **12/22**	**8/22** **10/20**	**10/24** **12/24**	**10/22** **12/20**	**10/24** **12/24**	**10/22** **12/20**	10/26 **12/24**	**10/22** **12/22**	10/26 **12/24**	**10/24** **12/22**	10/26 **12/24**
l = 4.75 m	**10/22** **12/20**	**12/24** **14/24**	**10/22** **12/22**	**12/24** **14/24**	**10/24** **12/22**	**12/26** **14/24**	**10/22** **12/22**	12/26 **14/24**	**10/24** **12/22**	12/26 **14/24**	**10/24** **12/22**	**10/26** **12/26**
l = 5.00 m	**10/22** **12/20**	12/26 **14/24**	**10/24** **12/22**	**14/24** 16/24	**10/24** **12/22**	**14/24** 16/24	**10/24** **12/22**	14/26 16/24	10/26 **12/24**	12/28 14/26	10/26 **12/24**	10/28 12/26
l = 5.25 m	**10/24** **12/22**	14/26 16/24	**12/24** **14/22**	14/26 16/24	**12/24** **14/22**	14/26 16/24	**12/24** **14/22**	14/28 16/26	10/26 **14/24**	14/28 16/26	10/26 **12/24**	10/28 12/26
l = 5.50 m	**12/24** **14/22**	14/28 16/26	12/26 **14/24**	14/28 16/26	**12/24** **14/22**	14/28 16/26	**12/24** **14/24**	14/28 16/26	12/26 **14/24**	14/30 16/28	12/26 **14/24**	12/30 14/28

Footnotes to Table 6.3.1 to 6.3.4

1) Bold: Preferred cross-section KVH ®, Duobalken ® or Triobalken ®

With gray background: Reduction in the cross-sectional height by 2 cm possible if Duobalken ® or Triobalken ® is used

2) Action:

g_k: Characteristic permanent action (dead weight) in accordance with DIN EN 1991-1

$q_{k,N}$: Characteristic variable action (live loads) in accordance with DIN EN 1991-1

3) Dimensioning criteria (left or right column)

A Stress resistance to flection $M_{R,d}$ and lateral force $V_{R,d}$

- Elastic deflection in the characteristic dimensioning situation: selected $w_{inst} \leq l/300$
- Final deflection in the quasi-permanent dimensioning situation: selected $w_{fin} \leq l/200$

B Dimensioning in compliance with the criteria of a vibration verification

- Natural frequency $f_1 \geq 8.0$ Hz
- Limitation of deflection to w = 1.5 mm under a load F = 1 kN in an unfavorable position (middle of beam)
- Ratio of pulse velocity v to a factor b resulting from the deflection w is smaller than 1 $(v/b^{(f_1 \zeta - 1)} \leq 1)$

Tab. 6.3.2 - Ceiling beam cross-sections, C24 (S10), simply supported beams, e = 62.5 cm for NKL 1 and 2 with medium load durations

Simply supported beam, e = 62.5 cm C24 (S10)	**Beam cross-section b/h [cm]**[1)] in dependency on span l and loads g_k and $q_{k,N}$											
Dead load[2)] g_k	1.75 kN/m²						2.50 kN/m²					
Live load[2)] $q_{k,N}$	2.00 kN/m²		2.80 kN/m²		3.00 kN/m²		2.00 kN/m²		2.80 kN/m²		3.00 kN/m²	
Dimensioning criterion[3)]	A	B	A	B	A	B	A	B	A	B	A	B
l = 3.00 m	**6/18** **8/16**	6/20 **8/18**	**6/18** **8/16**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	**6/18** **8/16**	6/20 **8/16**	**6/18** **8/16**	6/20 **8/18**	**6/18** **8/16**	6/20 **8/18**
l = 3.25 m	**6/18** **8/18**	6/22 **8/20**	6/20 **8/18**	6/22 **8/20**	6/20 **8/18**	6/22 **8/20**	**6/18** **8/16**	6/22 **8/22**	6/20 **8/18**	6/22 **8/20**	6/20 **8/18**	6/22 **8/20**
l = 3.50 m	6/20 **8/18**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/20 **8/18**	6/22 **8/20**	6/20 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**
l = 3.75 m	6/22 **8/20**	6/24 **8/22**	6/24 **8/20**	6/24 **8/22**	6/24 **8/22**	6/24 **8/22**	6/22 **8/20**	6/24 **8/22**	6/24 **8/20**	6/24 **8/22**	6/22 **8/20**	6/24 **8/22**
l = 4.00 m	**8/22** **10/20**	**8/24** **10/22**	**6/22** **10/20**	**8/24** **10/22**	**8/22** **10/20**	**8/24** **10/22**	**8/20** **10/20**	**8/24** **10/22**	**8/22** **10/20**	**8/24** **10/22**	**8/22** **10/20**	**8/24** **10/22**
l = 4.25 m	**8/22** **10/20**	**8/24** **10/24**	**8/24** **10/22**	**8/24** **10/24**	**8/24** **10/22**	8/26 **10/24**	**8/22** **10/20**	8/26 **10/24**	**8/24** **10/22**	8/26 10/24	**8/24** **10/22**	8/26 **10/24**
l = 4.50 m	**8/24** **10/22**	**10/24** **12/22**	**8/24** **10/22**	8/26 **10/24**	**10/24** **12/22**	10/26 **12/24**	**10/22** **12/20**	**10/24** **12/24**	**10/22** **12/22**	10/26 **12/24**	**10/24** **12/22**	10/26 **12/24**
l = 4.75 m	**8/24** **10/22**	10/24 **12/24**	8/22 **10/24**	8/28 12/24	**10/24** **12/24**	10/26 **12/24**	**10/22** 12/22	12/26 **14/24**	**10/24** **12/24**	12/26 **14/24**	**10/24** **12/22**	12/26 **14/24**
l = 5.00 m	8/26 **10/24**	10/28 12/26	8/26 10/26	10/28 12/26	10/26 **12/24**	10/28 12/26	**10/24** **12/24**	14/26 16/26	10/26 **12/24**	14/26 16/24	10/24 **12/24**	14/26 **16/24**
l = 5.25 m	8/26 **10/24**	12/28 14/26	8/28 10/26	10/30 12/28	12/26 **14/24**	12/28 14/26	**12/24** **14/22**	14/28 16/26	**12/24** **14/24**	14/28 16/26	12/26 **14/24**	14/28 16/26
l = 5.50 m	8/28 10/26	12/30 14/28	10/28 12/26	12/30 14/28	12/26 14/26	12/30 14/28	12/24 **14/22**	14/30 16/28	12/26 **14/24**	14/30 16/28	12/26 **14/24**	14/30 16/28

Tab. 6.3.3 - Ceiling beam cross-sections, C24 (S10), simply supported beams, e = 75.0 cm for NKL 1 and 2 with medium load durations

Simply supported beam, e = 75.0 cm C24 (S10)	**Beam cross-section b/h [cm][1)]** in dependency on span l and loads g_k and $q_{k.N}$											
Dead load[2)] g_k	1.75 kN/m²						2.50 kN/m²					
Live load[2)] $q_{k.N}$	2.00 kN/m²		2.80 kN/m²		3.00 kN/m²		2.00 kN/m²		2.80 kN/m²		3.00 kN/m²	
Dimensioning criterion[3)]	A	B	A	B	A	B	A	B	A	B	A	B
l = 3.00 m	**6/18** **8/16**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**
l = 3.25 m	6/20 **8/18**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/24 **8/20**	6/24 **8/20**	**8/20** **10/18**	**8/20** **10/20**
l = 3.50 m	6/22 8/20	6/24 **8/22**	6/24 **8/22**	6/24 **8/22**	6/24 **8/22**	6/24 **8/22**	6/24 **8/20**	6/24 **8/22**	6/26 **8/22**	6/24 **8/22**	8/22 **10/20**	8/22 **10/20**
l = 3.75 m	6/22 **8/20**	6/24 **8/22**	6/26 **8/22**	6/24 **8/22**	**8/22** **10/20**	**8/22** **10/20**	6/24 **8/22**	6/26 **8/24**	6/26 **8/24**	6/26 **8/24**	**10/22** **12/20**	**10/22** **12/22**
l = 4.00 m	**8/22** **10/20**	**8/24** **10/22**	**8/24** **10/22**	**8/24** **10/22**	**8/24** **10/22**	**8/24** **10/22**	**8/24** **10/22**	8/26 **10/24**	**8/24** **10/22**	8/26 **10/24**	**10/24** **12/22**	**10/24** **12/24**
l = 4.25 m	**8/24** **10/22**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	**8/24** **10/24**	10/26 12/26	8/26 **10/24**	10/26 12/26	**12/24** **14/22**	**12/26** **14/24**
l = 4.50 m	**10/24** **12/22**	10/26 **12/24**	**10/24** **12/22**	10/26 **12/24**	10/26 **12/24**	10/26 12/26	**10/24** **12/22**	10/28 12/26	10/26 **12/24**	10/28 12/26	**12/24** **14/24**	12/28 14/26
l = 4.75 m	**10/24** **12/24**	12/26 **14/24**	10/26 **12/24**	12/26 **14/24**	10/26 **12/24**	12/26 **14/24**	10/26 **12/24**	12/28 14/28	10/28 12/26	12/30 14/28	**14/24** **16/24**	14/28 16/26
l = 5.00 m	10/26 **12/24**	14/26 16/26	10/28 12/26	14/26 16/26	10/28 12/26	14/28 16/26	10/26 12/24	14/30 16/28	10/28 12/26	14/30 16/28	14/26 16/24	14/30 16/28
l = 5.25 m	12/26 **14/24**	14/28 16/26	12/26 14/26	14/30 16/28	12/28 14/26	14/28 16/26	12/26 14/26	14/32 16/30	12/28 14/26	14/32 16/30	14/28 16/26	14/32 16/30
l = 5.50 m	12/26 **14/24**	14/30 16/28	12/28 14/26	14/30 16/28	12/30 14/28	14/30 16/28	12/28 14/26	14/32 16/30	12/30 14/28	14/32 16/30	14/28 16/26	14/32 16/30

Tab. 6.3.4 - Ceiling beam cross-sections, C24 (S10), simply supported beams, e = 83.3 cm for NKL 1 and 2 with medium load durations

Simply supported beam, e = 83.3 cm C24 (S10)	**Beam cross-section b/h [cm]**[1)] in dependency on span l and loads g_k and $q_{k.N}$											
Dead load[2)] g_k	1.75 kN/m²						2.50 kN/m²					
Live load[2)] $q_{k.N}$	2.00 kN/m²		2.80 kN/m²		3.00 kN/m²		2.00 kN/m²		2.80 kN/m²		3.00 kN/m²	
Dimensioning criterion[3)]	A	B	A	B	A	B	A	B	A	B	A	B
l = 3.00 m	6/20 **8/18**	6/20 **8/18**	6/22 **8/18**	6/22 **8/18**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**	6/24 **8/20**	6/24 **8/20**
l = 3.25 m	6/20 **8/18**	6/22 **8/20**	6/24 **8/20**	6/24 **8/20**	6/24 **8/20**	6/24 **8/20**	6/22 **8/20**	6/22 **8/20**	6/24 **8/22**	6/24 **8/22**	8/22 **10/20**	8/22 **10/20**
l = 3.50 m	6/22 8/20	6/22 8/20	6/24 8/22	6/24 8/22	6/26 8/22	6/26 8/22	6/24 8/22	6/26 8/24	8/24 10/20	8/24 10/22	8/24 10/22	8/24 10/22
l = 3.75 m	6/24 **8/22**	6/24 **8/22**	6/26 **8/24**	6/26 **8/22**	6/28 **8/24**	6/28 **8/24**	**8/22** **10/20**	8/26 **10/24**	**8/24** **10/22**	**8/26** **10/24**	**10/24** **12/22**	**10/24** **12/22**
l = 4.00 m	**8/22** **10/22**	**8/24** **10/22**	**8/24** **10/22**	**8/24** **10/22**	8/26 **10/24**	8/26 **10/24**	**8/24** **10/22**	8/28 10/26	**10/24** **12/22**	10/26 **12/24**	**10/24** **12/22**	10/26 **12/24**
l = 4.25 m	**8/24** **10/22**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	**10/24** **12/22**	10/24 12/26	10/26 **12/24**	10/28 12/26	**12/24** **14/22**	12/26 **14/24**
l = 4.50 m	8/26 **10/24**	8/28 10/26	10/26 **12/24**	10/26 12/26	10/26 **12/24**	10/26 12/26	10/26 **12/24**	10/30 12/28	**12/24** **14/24**	12/28 14/26	12/26 **14/24**	12/28 14/26
l = 4.75 m	10/26 **12/24**	10/28 12/26	10/26 12/26	12/26 12/26	10/26 12/26	12/26 14/26	12/26 **14/24**	12/30 14/28	14/26 16/24	14/28 16/26	14/26 16/24	14/28 16/28
l = 5.00 m	10/26 **12/24**	10/30 12/28	10/28 12/26	10/30 12/28	10/28 12/26	14/28 16/26	12/26 **14/24**	12/32 14/30	14/26 16/26	14/30 16/28	14/26 16/26	14/30 16/30
l = 5.25 m	12/26 **14/24**	12/30 14/30	12/28 14/26	12/30 14/28	12/28 14/26	12/30 14/28	12/28 14/26	14/32 16/30	14/28 16/26	14/32 16/30	14/28 16/26	14/32 16/30
l = 5.50 m	12/28 14/26	12/30 14/30	12/30 14/28	12/32 14/30	12/30 14/28	14/32 16/30	12/28 14/28	14/32 16/30	14/30 16/28	14/32 16/32	14/30 16/28	14/32 16/30

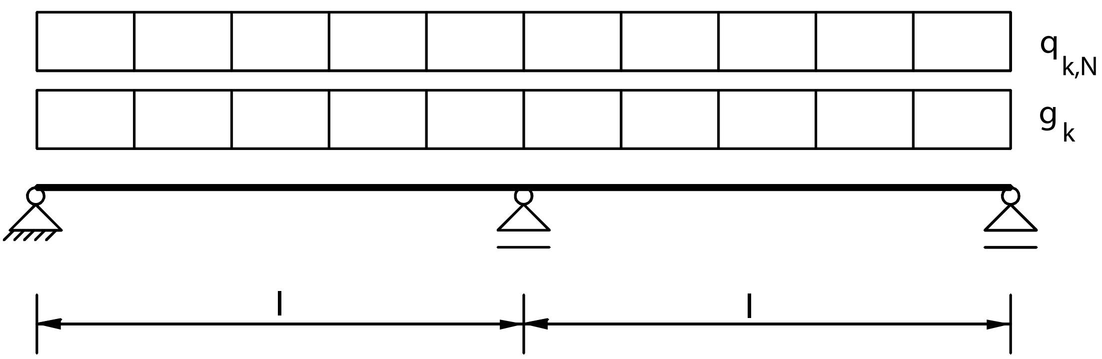
1);2);3) The footnotes to Table 6.3.1 apply

Ceiling beam cross-sections for double span beams

Tab. 6.3.5 - Ceiling beam cross-sections, C24 (S10), double span beams, e = 50.0 cm for NKL 1 and 2 with medium load durations

Double span beam e = 50.0 cm C24 (S10)	Beam cross-section b/h [cm][1)] in dependency on span l and loads g_k und $q_{k,N}$											
Dead load[2)] g_k	1.75 kN/m²						2.50 kN/m²					
Live load[2)] $q_{k,N}$	2.00 kN/m²		2.80 kN/m²		3.00 kN/m²		2.00 kN/m²		2.80 kN/m²		3.00 kN/m²	
Dimensioning criterion[3)]	A	B	A	B	A	B	A	B	A	B	A	B
l = 3.00 m	6/16 8/14	6/18 8/16	6/16 8/14	6/18 8/16	6/18 8/16	6/18 8/16	6/16 8/14	6/18 8/16	6/18 8/16	6/18 8/16	6/18 8/16	6/18 8/16
l = 3.25 m	6/18 8/16	6/22 8/18	6/18 8/16	6/20 8/18	6/18 8/16	6/20 8/18	6/18 8/16	6/20 8/18	6/20 8/16	6/20 8/18	6/20 8/18	6/20 8/18
l = 3.50 m	6/18 8/16	6/20 8/20	6/20 8/16	6/20 8/18	6/20 8/18	6/20 8/18	6/20 8/16	6/22 8/20	6/20 8/18	6/22 8/20	6/22 8/18	6/22 8/20
l = 3.75 m	6/20 8/18	6/22 8/20	6/20 8/18	6/22 8/20	6/22 8/18	6/22 8/20	6/20 8/18	6/24 8/22	6/22 8/20	6/24 8/22	6/22 8/20	6/24 8/22
l = 4.00 m	6/20 8/18	6/22 8/20	6/22 8/20	6/24 8/22	6/22 8/20	6/24 8/22	6/22 8/18	6/26 8/24	6/24 8/20	6/26 8/24	6/24 8/20	6/26 8/24
l = 4.25 m	6/22 8/18	6/24 8/22	6/24 8/20	6/24 8/22	8/20 10/18	8/22 10/22	6/24 8/20	6/28 8/26	6/24 8/22	6/28 8/26	8/22 10/20	8/26 10/24
l = 4.50 m	6/22 8/20	6/26 8/24	6/24 8/22	6/26 8/24	8/22 10/20	8/24 10/22	6/24 8/22	8/28 10/26	8/24 10/20	8/28 10/26	8/24 10/22	8/28 10/26
l = 4.75 m	6/24 8/20	6/28 8/26	8/22 10/20	8/26 10/24	8/24 10/20	8/26 10/24	8/22 10/20	8/30 10/28	8/24 10/22	8/30 10/28	10/22 12/20	10/28 12/26
l = 5.00 m	6/24 8/22	8/28 10/26	8/24 10/22	10/26 10/26	10/22 12/20	10/22 12/24	8/24 10/22	10/30 12/28	10/22 12/22	10/30 12/28	10/24 12/28	10/30 12/28
l = 5.25 m	8/22 10/20	10/30 10/28	8/24 10/22	8/30 10/28	10/22 12/20	10/28 12/26	8/24 10/22	10/30 12/28	10/24 12/22	10/30 12/28	12/22 14/20	12/30 14/28
l = 5.50 m	8/24 10/22	10/30 12/28	10/24 10/22	10/30 12/28	12/22 14/20	12/28 14/26	10/24 12/22	12/30 14/28	12/24 14/22	12/30 14/30	12/24 14/22	12/30 14/30
l = 5.75 m	10/22 12/20	10/32 12/30	10/24 12/22	10/30 12/28	12/22 14/22	12/30 14/28	10/24 12/22	12/32 14/30	14/22 16/20	14/30 16/28	14/22 16/22	14/32 16/30
l = 6.00 m	10/24 12/22	12/30 14/28	12/24 14/22	12/30 14/28	12/24 14/22	14/30 16/28	12/24 14/22	14/32 16/30	14/24 16/22	14/32 16/30	14/24 16/22	14/32 16/30

See page 31 for footnotes ➟



Tab. 6.3.6 - Ceiling beam cross-sections, C24 (S10), double span beams, e = 62.5 cm for NKL 1 and 2 with medium load durations I

Double span beam **e = 62.5 cm** **C24 (S10)**	**Beam cross-section b/h [cm]**[1] in dependency on span l and loads g_k und $q_{k,N}$											
Dead load[2] g_k	1.75 kN/m²						2.50 kN/m²					
Live load[2] $q_{k,N}$	2.00 kN/m²		2.80 kN/m²		3.00 kN/m²		2.00 kN/m²		2.80 kN/m²		3.00 kN/m²	
Dimensioning criterion[3]	A	B	A	B	A	B	A	B	A	B	A	B
l = 3.00 m	**6/16** **8/14**	**6/18** **8/16**	**6/18** **8/16**	**6/18** **8/16**	**6/20** **8/18**	**6/18** **8/16**	**6/18** **8/16**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**
l = 3.25 m	6/18 8/16	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/20 **8/18**	6/22 **8/20**	6/22 **8/18**	6/22 **8/20**	6/22 **8/20**	6/22 **8/20**
l = 3.50 m	6/20 **8/18**	6/20 **8/18**	6/22 **8/18**	6/20 **8/20**	6/22 **8/20**	6/20 **8/20**	6/22 **8/18**	6/24 **8/22**	6/24 **8/20**	6/24 **8/22**	6/24 **8/20**	6/24 **8/22**
l = 3.75 m	6/20 **8/18**	6/22 **8/20**	6/24 **8/20**	6/22 **8/20**	6/24 8/20	6/22 **8/20**	6/22 **8/20**	6/26 **8/24**	6/24 **8/22**	6/26 **8/24**	**8/22** **10/20**	**8/24** **10/22**
l = 4.00 m	**8/20** **10/20**	**8/22** **10/20**	**8/22** **10/20**	**8/22** **10/20**	**8/22** **10/20**	**8/22** **10/20**	**8/22** **10/18**	8/26 **10/24**	**8/22** **10/20**	8/26 **10/24**	**8/24** **10/20**	8/26 **10/24**
l = 4.25 m	**8/20** **10/18**	**8/24** **10/22**	**8/22** **10/20**	**8/24** **10/22**	**8/24** **10/20**	**8/24** **10/22**	**8/22** **10/20**	8/26 10/26	**8/24** **10/22**	8/28 10/26	**10/22** **12/20**	10/26 **12/24**
l = 4.50 m	**10/20** **12/18**	**10/24** **12/22**	**10/22** **12/20**	**10/24** **12/22**	**10/22** **12/20**	**10/20** **12/22**	**8/24** **10/22**	10/28 12/26	**10/24** **12/22**	10/28 12/26	**10/24** **12/22**	10/28 12/26
l = 4.75 m	**10/20** **12/18**	**12/24** **14/24**	**10/22** **12/20**	**12/24** **14/24**	**10/24** **12/22**	**12/24** **14/22**	**8/24** **10/22**	10/30 12/28	**10/24** **12/22**	10/30 12/28	**12/22** **14/22**	12/28 14/26
l = 5.00 m	**10/22** **12/20**	12/26 **14/24**	**10/24** **12/22**	12/26 **14/24**	**10/24** **12/22**	**12/24** **14/24**	**10/24** **12/22**	12/30 14/28	**12/24** **14/22**	12/30 14/28	**12/24** **14/22**	12/28 16/26
l = 5.25 m	**10/22** **12/20**	14/26 16/26	**10/24** **12/22**	14/26 16/26	10/26 **12/24**	14/26 16/26	**10/24** **12/22**	12/32 14/30	**12/24** **14/22**	14/30 16/30	**12/24** **14/24**	14/30 16/28
l = 5.50 m	**12/22** **14/20**	14/28 16/26	**12/24** **14/22**	14/28 16/26	**12/24** **14/22**	14/28 16/26	**12/24** **14/22**	14/32 16/30	**14/24** 16/22	14/32 16/30	**14/24** 16/22	14/32 16/30
l = 5.75 m	**12/22** **14/20**	14/30 16/28	**12/24** **14/24**	14/30 16/28	12/26 **14/24**	14/30 16/28	**12/24** **14/22**	14/34 16/32	**14/24** 16/24	14/32 16/30	14/26 16/24	14/32 16/30
l = 6.00 m	**14/22** 16/20	14/32 16/30	**14/24** 16/22	14/32 16/30	**14/24** 16/24	14/32 16/30	**14/24** 16/22	14/32 16/32	14/26 16/24	14/32 16/30	14/26 16/24	14/32 16/30

Footnotes to Table 6.3.5 and 6.3.6

1) Bold: Preferred cross-section KVH ®, Duobalken ® or Triobalken ®
With gray background: Reduction in the cross-sectional height by 2 cm possible if Duobalken ® or Triobalken ® is used

2) Action:
g_k: Characteristic permanent action (dead weight) in accordance with DIN EN 1991-1
$q_{k,N}$: Characteristic variable action (live loads) in accordance with DIN EN 1991-1

3) Dimensioning criteria (left or right column)

A Stress resistance to flection $M_{R,d}$ and lateral force $V_{R,d}$

- Elastic deflection in the characteristic dimensioning situation: selected $w_{inst} \leq l/300$
- Final deflection in the quasi-permanent dimensioning situation: selected $w_{fin} \leq l/200$

B Dimensioning in compliance with the criteria of a vibration verification

- Natural frequency $f_1 \geq 8.0$ Hz
- Limitation of deflection to w = 1.5 mm under a load F = 1 kN in an unfavorable position (middle of beam)
- Ratio of pulse velocity v to a factor b resulting from the deflection w is smaller than 1 $(v/b^{(f_1 \zeta - 1)} \leq 1)$

Tab. 6.3.7 - Ceiling beam cross-sections, C24 (S10), double span beams, e = 75.0 cm for NKL 1 and 2 with medium load durations

Double span beam e = 75.0 cm C24 (S10)	Beam cross-section b/h [cm][1)] in dependency on span l and loads g_k und $q_{k.N}$											
Dead load[2)] g_k	1.75 kN/m²						2.50 kN/m²					
Live load[2)] $q_{k.N}$	2.00 kN/m²		2.80 kN/m²		3.00 kN/m²		2.00 kN/m²		2.80 kN/m²		3.00 kN/m²	
Dimensioning criterion[3)]	A	B	A	B	A	B	A	B	A	B	A	B
l = 3.00 m	6/18 8/16	6/18 8/16	6/20 8/18	6/20 8/18	6/20 8/18	6/20 8/18	6/20 8/18	6/20 8/18	6/22 8/18	6/22 8/20	6/22 8/20	6/22 8/20
l = 3.25 m	6/20 8/18	6/20 8/18	6/22 8/20	6/22 8/20	6/22 8/20	6/22 8/20	6/22 8/20	6/22 8/20	6/24 8/20	6/24 8/22	6/24 8/22	6/24 8/22
l = 3.50 m	6/22 8/18	6/22 8/20	6/24 8/20	6/24 8/20	6/24 8/22	6/24 8/22	6/24 8/20	6/24 8/22	8/22 10/20	8/22 10/20	8/22 10/20	8/22 10/20
l = 3.75 m	6/22 8/20	6/24 8/22	6/26 8/22	6/26 8/22	8/22 10/20	8/22 10/20	6/24 8/22	6/26 8/24	8/24 10/22	8/24 1022	8/24 10/22	8/24 10/22
l = 4.00 m	8/22 10/20	8/22 10/22	8/24 10/20	8/24 10/22	8/24 10/22	8/24 10/22	8/24 10/20	8/26 10/24	8/26 10/22	8/06 10/24	8/26 10/22	8/26 10/24
l = 4.25 m	8/22 10/20	8/26 10/24	8/24 10/22	8/26 10/24	10/22 12/20	10/24 12/22	8/24 10/22	8/28 10/26	10/24 12/22	10/26 12/26	10/24 12/22	10/26 12/26
l = 4.50 m	8/24 10/22	8/28 10/26	10/24 12/22	10/26 12/24	10/24 12/22	10/26 12/24	10/24 12/22	10/30 12/28	10/26 12/24	10/28 12/28	10/26 12/24	10/28 12/28
l = 4.75 m	8/26 10/22	8/30 10/28	10/24 12/22	12/26 14/24	12/24 14/22	12/26 14/24	10/24 12/22	10/30 12/28	10/26 12/24	10/30 12/28	10/28 12/24	10/30 12/28
l = 5.00 m	10/24 12/22	10/30 12/28	12/24 14/22	12/28 14/26	12/24 14/22	12/28 14/28	12/24 14/22	14/30 16/28	12/26 14/24	14/30 16/28	12/26 14/24	14/30 16/28
l = 5.25 m	10/24 12/22	12/30 14/28	12/24 14/24	12/30 14/28	14/26 14/24	12/30 14/28	12/24 14/22	14/32 16/30	12/26 14/24	14/32 16/30	12/28 14/26	12/32 14/30
l = 5.50 m	12/24 14/22	12/32 14/30	12/26 14/24	14/30 16/28	12/26 14/24	14/30 16/28	14/24 16/22	14/32 16/30	14/26 16/24	14/32 16/30	14/26 16/24	14/32 16/30
l = 5.75 m	12/24 14/22	14/32 14/30	14/26 16/24	14/32 16/30	14/26 16/24	14/32 16/30	14/24 16/24	14/34 16/32	14/28 16/26	14/32 16/30	14/28 16/26	14/32 16/30
l = 6.00 m	14/24 16/22	14/32 16/30	14/26 16/24	14/32 16/30	14/26 16/26	14/32 16/30	14/26 16/24	14/32 16/30	14/28 16/26	14/32 16/30	14/28 16/28	14/32 16/30

See page 31 for footnotes

Tab. 6.3.8 - Ceiling beam cross-sections, C24 (S10), double span beams, e = 83.3 cm for NKL 1 and 2 with medium load durations

Double span beam **e = 83.3 cm** **C24 (S10)**	**Beam cross-section b/h [cm][1)]** in dependency on span l and loads g_k und $q_{k.N}$											
Dead load[2)] g_k	1.75 kN/m²						2.50 kN/m²					
Live load[2)] $q_{k.N}$	2.00 kN/m²		2.80 kN/m²		3.00 kN/m²		2.00 kN/m²		2.80 kN/m²		3.00 kN/m²	
Dimensioning criterion[3)]	A	B	A	B	A	B	A	B	A	B	A	B
l = 3.00 m	6/20 **8/16**	6/20 **8/18**	6/22 **8/18**	**6/18** **8/18**	6/22 **8/20**	6/22 **8/20**	6/22 **8/18**	6/22 **8/18**	6/22 **8/20**	6/22 **8/20**	6/24 **8/20**	6/24 **8/20**
l = 3.25 m	6/20 **8/18**	6/20 **8/18**	6/24 **8/20**	6/20 **8/18**	6/24 **8/20**	6/24 **8/20**	6/22 **8/20**	6/22 **8/20**	6/24 **8/22**	6/24 **8/22**	6/26 **8/22**	6/26 **8/22**
l = 3.50 m	6/22 **8/20**	6/22 **8/20**	6/24 **8/22**	6/24 **8/22**	6/26 8/22	6/26 **8/22**	6/24 **8/22**	6/26 **8/24**	6/26 **8/24**	6/26 **8/24**	6/28 **8/24**	6/28 **8/24**
l = 3.75 m	6/24 **8/20**	6/24 **8/22**	6/26 **8/24**	6/26 **8/24**	6/28 **8/24**	6/28 **8/24**	**8/22** **10/20**	**8/24** **10/24**	**8/24** **10/22**	8/26 **10/24**	6/28 8/26	6/28 8/26
l = 4.00 m	**8/22** **10/20**	**8/24** **10/22**	**8/24** **10/22**	**8/24** **10/22**	8/26 **10/24**	8/26 **10/24**	**8/24** **10/22**	8/28 10/26	8/26 **10/24**	8/28 10/26	8/26 **10/24**	8/28 10/26
l = 4.25 m	**8/24** **10/22**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	8/26 **10/24**	**10/24** **12/22**	10/28 12/26	10/26 **12/22**	10/28 12/26	8/28 10/26	8/30 10/28
l = 4.50 m	**10/22** **12/20**	10/26 12/26	**10/24** **12/22**	10/26 12/26	10/26 **12/24**	10/26 **12/24**	**10/24** **12/22**	10/30 12/28	10/26 **12/24**	10/30 12/28	10/26 **12/24**	10/30 12/28
l = 4.75 m	**10/24** **12/22**	10/28 12/26	10/26 **12/24**	12/26 14/26	10/26 **12/24**	10/28 12/26	**12/24** **14/22**	12/30 14/28	10/28 12/26	12/30 14/28	10/28 12/26	12/30 14/28
l = 5.00 m	**10/24** **12/22**	10/30 12/28	10/28 12/26	12/28 14/28	10/28 12/26	12/28 14/28	**12/24** **14/22**	14/30 16/30	12/26 **14/24**	12/32 14/30	10/30 12/28	12/32 14/30
l = 5.25 m	10/26 **12/24**	12/30 14/28	10/28 12/26	14/30 16/28	10/30 12/28	12/30 14/28	12/26 14/24	14/32 16/30	12/28 14/26	14/32 16/30	12/30 14/26	14/32 16/30
l = 5.50 m	**12/24** **14/22**	14/30 16/28	12/28 14/26	14/30 16/30	12/28 14/26	14/30 16/28	14/26 16/24	14/32 16/30	14/28 16/26	14/32 16/30	12/30 14/28	14/32 16/30
l = 5.75 m	**14/24** 16/22	14/32 16/30	12/28 14/26	14/30 16/28	14/28 16/26	14/32 16/30	14/26 16/24	14/32 16/30	14/28 16/26	14/32 16/30	14/30 16/28	14/32 16/30
l = 6.00 m	14/26 16/24	14/32 16/30	12/30 14/28	14/30 16/30	14/30 16/28	14/32 16/30	14/28 16/26	14/32 16/30	14/30 16/28	14/32 16/30	14/30 16/28	14/32 16/30

6.3 Dimensioning of Posts

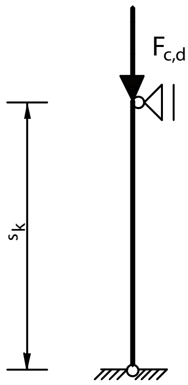
Tab. 6.4.1 - Dimensioning values for load-bearing capacity $R_{c,d}$ for single-piece posts, C24 (S10), with articulated support on both sides[1)], for NKL 1 and 2 with medium load durations

C24 (S10)	**$R_{c,d}$ [kN] in dependency on buckling length s_k [m][2)]**															
b/h [cm]	2.50		3.00		3.50		4.00		4.50		5.00		5.50		6.00	
	KVH	DTB	KVH	DTB	KVH	DTB	KVH	DTB	KVH	DTB	KVH	DTB	KVH	DTB	KVH	DTB
6/10	7.97	8.31	5.62	5.86	4.17	4.35	3.22	3.36	2.56	2.67	2.08	2.17	1.72	1.80	1.45	1.52
6/12	9.57	9.98	6.74	7.04	5.00	5.22	3.86	4.03	3.07	3.20	2.49	2.60	2.07	2.16	1.74	1.82
6/14	11.16	11.64	7.87	8.21	5.84	6.09	4.50	4.70	3.58	3.74	2.91	3.04	2.41	2.52	2.03	2.12
6/16	12.76	13.30	8.99	9.38	6.67	6.96	5.15	5.37	4.09	4.27	3.33	3.47	2.76	2.88	2.33	2.43
6/18	14.35	14.96	10.12	10.55	7.51	7.83	5.79	6.04	4.60	4.80	3.74	3.91	3.10	3.24	2.62	2.73
6/20	15.94	16.63	11.24	11.73	8.34	8.71	6.43	6.72	5.11	5.34	4.16	4.34	3.45	3.60	2.91	3.03
6/22	17.54	18.29	12.36	12.90	9.18	9.58	7.08	7.39	5.62	5.87	4.57	4.78	3.79	3.96	3.20	3.34
6/24	19.13	19.95	13.49	14.07	10.01	10.45	7.72	8.06	6.13	6.40	4.99	5.21	4.14	4.32	3.49	3.64
8/10	18.24	18.99	12.98	13.53	9.68	10.10	7.49	7.82	5.97	6.23	4.86	5.08	4.04	4.22	3.41	3.56
8/12	21.89	22.79	15.58	16.24	11.62	12.12	8.99	9.38	7.16	7.47	5.84	6.09	4.85	5.06	4.09	4.27
8/14	25.53	26.59	18.17	18.94	13.56	14.14	10.49	10.95	8.35	8.72	6.81	7.11	5.65	5.90	4.77	4.98
8/16	29.18	30.38	20.77	21.65	15.49	16.16	11.99	12.51	9.55	9.96	7.78	8.12	6.46	6.75	5.45	5.69
8/18	32.83	34.18	23.37	24.36	17.43	18.18	13.49	14.07	10.74	11.21	8.75	9.14	7.27	7.59	6.13	6.40
8/20	36.48	37.98	25.96	27.06	19.37	20.20	14.99	15.64	11.94	12.45	9.73	10.15	8.08	8.43	6.81	7.11
8/22	40.12	41.78	28.56	29.77	21.31	22.22	16.49	17.20	13.13	13.70	10.70	11.17	8.89	9.28	7.50	7.83
8/24	43.77	45.57	31.15	32.47	23.24	24.24	17.98	18.76	14.32	14.95	11.67	12.18	9.69	10.12	8.18	8.54
10/10	33.96	35.26	24.57	25.57	18.47	19.25	14.36	14.97	11.47	11.96	9.37	9.77	7.79	8.13	6.58	6.87
10/12	40.75	42.31	29.48	30.68	22.17	23.10	17.23	17.97	13.76	14.36	11.24	11.73	9.35	9.76	7.90	8.24
10/14	47.54	49.37	34.39	35.80	25.86	26.95	20.10	20.96	16.06	16.75	13.11	13.68	10.91	11.38	9.21	9.62
10/16	54.34	56.42	39.31	40.91	29.56	30.80	22.98	23.96	18.35	19.14	14.99	15.64	12.47	13.01	10.53	10.99
10/18	61.13	63.47	44.22	46.03	33.25	34.65	25.85	26.95	20.65	21.53	16.86	17.59	14.02	14.63	11.85	12.36
10/20	67.92	70.52	49.13	51.14	36.95	38.50	28.72	29.94	22.94	23.93	18.73	19.55	15.58	16.26	13.16	13.74
10/22	74.71	77.58	54.05	56.25	40.64	42.35	31.59	32.94	25.23	26.32	20.61	21.50	17.14	17.89	14.48	15.11
10/24	81.51	84.63	58.96	61.37	44.34	46.20	34.46	35.93	27.53	28.71	22.48	23.45	18.70	19.51	15.79	16.48
12/12	65.76	67.94	48.90	50.78	37.23	38.74	29.14	30.35	23.37	24.36	19.13	19.95	15.95	16.63	13.49	14.07
12/14	76.71	79.27	57.05	59.24	43.44	45.20	33.99	35.41	27.26	28.42	22.32	23.28	18.60	19.40	15.74	16.42
12/16	87.67	90.59	65.20	67.70	49.65	51.66	38.85	40.47	31.15	32.47	25.51	26.60	21.26	22.18	17.98	18.76
12/18	98.63	101.92	73.36	76.17	55.85	58.12	43.70	45.53	35.05	36.53	28.70	29.93	23.92	24.95	20.23	21.11
12/20	109.59	113.24	81.51	84.63	62.06	64.57	48.56	50.58	38.94	40.59	31.89	33.25	26.58	27.72	22.48	23.45
12/22	120.55	124.56	89.66	93.09	68.26	71.03	53.42	55.64	42.84	44.65	35.08	36.58	29.23	30.49	24.73	25.80
12/24	131.51	135.89	97.81	101.55	74.47	77.49	58.27	60.70	46.73	48.71	38.27	39.90	31.89	33.27	26.98	28.15
14/14	110.39	113.26	85.73	88.67	66.56	69.11	52.60	54.72	42.42	44.18	34.86	36.33	29.12	30.36	24.68	25.74
14/16	126.16	129.44	97.98	101.34	76.07	78.99	60.12	62.54	48.48	50.49	39.84	41.52	33.29	34.70	28.21	29.42
14/18	141.93	145.62	110.22	114.00	85.58	88.86	67.63	70.36	54.54	56.80	44.82	46.71	37.45	39.04	31.73	33.09
14/20	157.70	161.81	122.47	126.67	95.09	98.73	75.15	78.18	60.60	63.11	49.80	51.90	41.61	43.38	35.26	36.77
14/22	173.47	177.99	134.72	139.34	104.60	108.61	82.66	85.99	66.66	69.43	54.78	57.09	45.77	47.72	38.78	40.45
14/24	189.24	194.17	146.96	152.01	114.11	118.48	90.18	93.81	72.73	75.74	59.76	62.28	49.93	52.05	42.31	44.12
16/16	165.38	168.44	135.64	139.53	108.42	112.21	86.94	90.27	70.68	73.51	58.36	60.77	48.91	50.96	41.54	43.30
16/20	206.73	210.54	169.55	174.41	135.53	140.27	108.67	112.84	88.35	91.89	72.95	75.96	61.14	63.70	51.92	54.12
16/22	227.40	231.60	186.51	191.85	149.08	154.29	119.54	124.12	97.18	101.08	80.25	83.55	67.25	70.07	57.12	59.54
16/24	248.07	252.65	203.47	209.29	162.63	168.32	130.41	135.41	106.02	110.27	87.54	91.15	73.37	76.44	62.31	64.95
18/18	227.88	230.78	196.99	201.35	163.48	168.45	133.83	138.58	110.03	114.25	91.46	95.12	76.97	80.13	65.56	68.29
18/20	253.20	256.43	218.88	223.72	181.64	187.16	148.70	153.98	122.26	126.94	101.62	105.69	85.53	89.03	72.84	75.88
18/22	278.52	282.07	240.77	246.09	199.81	205.88	163.57	169.37	134.48	139.64	111.79	116.26	94.08	97.94	80.12	83.46
18/24	303.84	307.71	262.66	268.46	217.97	224.59	178.44	184.77	146.71	152.33	121.95	126.82	102.63	106.84	87.41	91.05
20/20	296.71	299.40	267.08	271.44	230.67	236.42	193.97	200.10	161.96	167.76	135.84	141.05	114.96	119.54	98.27	102.28
20/22	326.38	329.34	293.79	298.58	253.74	260.06	213.36	220.12	178.16	184.54	149.43	155.15	126.46	131.49	108.09	112.51
20/24	356.05	359.27	320.50	325.73	276.81	283.70	232.76	240.13	194.35	201.32	163.01	169.26	137.95	143.45	117.92	122.73
24/24	453.41	455.81	427.26	431.13	392.57	398.43	350.21	357.95	305.20	313.93	263.02	271.78	226.37	234.60	195.61	203.11

-KVH = KVH® structural finger-jointed timber - Preferred cross-sections of KVH® are shown in bold print

- DTB = Duobalken® / Triobalken®

The strength values contained in EN 338 apply. The calculation of λ_{rel} takes a modulus of elasticity of $E_{0.05}$ into consideration. The value for softwood is specified as 7,400 N/mm2 in Table 1. This value is determined from the modulus of elasticity of $E_{0.mean}$ ($E_{0.05} = 0.67 * E_{0.mean}$) in all cases. If this is applied to Duobalken® and Triobalken®, the result with a modulus of elasticity of 11.600 N/mm² is a $E_{0.05}$ = 11.600 * 0.67 = 7.772 N/mm². This has positive results in respect of the load-bearing capacity of compression struts made of Duobalken® und Triobalken® compared to KVH®. However, the increase varies according to the specific situation (buckling length / cross-section) from between 2.05 to 4.93%. A standard increase factor for the substitution of KVH® with Duobalken® and Triobalken® is therefore not possible. This means that either the potential for increase associated with the use of Duobalken® and Triobalken® can be ignored, or the values for load-bearing capacity given in the table can be applied separately for KVH® and Duobalken® / Triobalken®.



Single-piece post

The dimensioning values are determined for buckling along the weak (decisive) axis for a medium load duration (residential, office buildings) in Service Classes 1 and 2: The resultant modification factor:

k_{mod} = 0.8;

partial safety factor for solid timber/glued solid timber: γ_M = 1.3

tabulation makes the following simplified approaches necessary:- partial safety value on the load side:

$g_G = g_Q = 1.5$;

- combination factor ψ_o = 1.0

6.5 Dimensioning of Rafters

Preliminary remarks: The following dimensioning reference tables were developed for rafters in purlin roof structures. The values for the load action (wind and snow loads) applied here are based on roof areas larger than 10 m². Additional structures on the roof such as, e.g. photovoltaic units or snow guards, and trimmings, e.g. for skylights, must be taken into consideration separately in the building-specific verification.

Footnotes to Tables 6.5.1 to 6.5.4

[1] **Bold** = Preferred cross-section of KVH® or Duobalken®, Triobalken®

Action:

g_k: Characteristic permanent action (dead weight) in accordance with DIN 1055-1: 2002-06

s_k: Characteristic value for snow load on the ground in accordance with DIN 1055-5: 2005-07

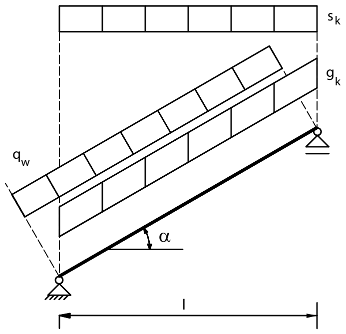
q_w: Wind pressure in accordance with DIN 1055-4: 2005-03

(q_w = 0.9 kN/m² corresponds to wind zone 2 up to h = 10 m above ground level)

TAB. 6.5.1

Rafter cross-sections for simply supported beams

Table 6.5.1 - Rafter cross-sections, C24 (S10), s_k = 0.85 kN/m² for NKL 1 and 2 with medium load durations

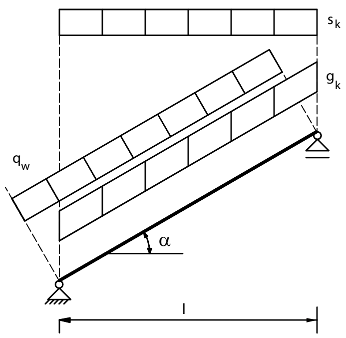


Rafter in the form of a simply supported beam

Simply supported beam - C24 (S10) g_k = 1.20 kN/m² s_k = 0.85 kN/m² q_w = 0.90 kN/m²		Rafter cross-section b/h [cm][1)] in dependency on roof pitch, rafter spacing e and span l					
		α = 5° - 25°			α = 26° - 35°		
Rafter spacing [m]		0.625	0.75	0.833	0.625	0.75	0.833
Maximum span (area)	l = 2.50 m	6/14 8/12	6/14 8/14	6/14 8/14	6/14 8/14	6/14 8/14	6/16 8/14
	l = 3.00 m	6/16 8/16	6/18 8/16	6/18 8/16	6/18 8/16	6/18 8/16	6/18 8/16
	l = 3.50 m	6/20 8/18	6/20 8/18	6/20 8/18	6/20 8/18	6/22 8/20	6/22 8/20
	l = 4.00 m	6/22 8/20	6/22 8/20	6/22 8/20	6/24 8/22	6/24 8/22	6/24 8/22
	l = 4.50 m	6/24 8/22	6/26 8/22	6/26 8/24	6/26 8/24	6/26 8/24	8/24 8/24
Roof pitch		α = 36° - 45°			α = 46° - 55°		
Rafter spacing (m)		0.625	0.75	0.833	0.625	0.75	0.833
Maximum span (area)	l = 2.50 m	6/16 8/14	6/16 8/16	6/16 8/16	6/20 8/18	6/20 8/18	6/20 8/18
	l = 3.00 m	6/20 8/18	6/20 8/18	6/20 8/18	6/24 8/22	6/24 8/22	6/24 8/22
	l = 3.50 m	6/24 8/20	6/22 8/20	6/24 8/22	8/24 10/22	8/26 10/24	8/26 10/24
	l = 4.00 m	6/26 8/22	6/26 8/24	6/26 8/24	10/26 12/24	10/28 12/26	10/28 12/26
	l = 4.50 m	8/26 10/24	8/26 10/24	8/26 10/26	10/30 14/26	10/30 14/28	10/32 16/24

TAB. 6.5.2

Table 6.5.2 - Rafter cross-sections, C24 (S10), s_k = 1.10 kN/m² for NKL 1 and 2 with medium load durations



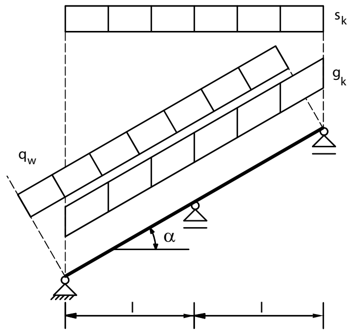
Rafter in the form of a simply supported beam

Simply supported beam - C24 (S10) g_k = 1.20 kN/m² s_k = 1.10 kN/m² q_w = 0.90 kN/m²		Rafter cross-section b/h [cm][1)] in dependency on roof pitch, rafter spacing e and span l					
		α = 5° - 25°			α = 26° - 35°		
Rafter spacing [m]		0.625	0.75	0.833	0.625	0.75	0.833
Maximum span (area)	l = 2.50 m	6/14 8/14	6/14 8/14	6/16 8/14	6/16 8/14	6/16 8/14	6/16 8/14
	l = 3.00 m	6/18 8/16	6/18 8/16	6/18 8/16	6/18 8/16	6/18 8/16	6/18 8/16
	l = 3.50 m	6/20 8/18	6/20 8/18	6/20 8/18	6/22 8/20	6/22 8/20	6/22 8/20
	l = 4.00 m	6/22 8/20	6/24 8/24	6/24 8/22	6/24 8/22	6/24 8/22	6/24 8/22
	l = 4.50 m	6/26 8/24	8/24 10/22	8/24 8/24	8/24 10/22	8/26 10/24	8/26 10/24
Roof pitch		α = 36° - 45°			α = 46° - 55°		
Rafter spacing (m)		0.625	0.75	0.833	0.625	0.75	0.833
Maximum span (area)	l = 2.50 m	6/16 8/14	6/16 8/14	6/18 8/16	6/20 8/18	6/20 8/18	6/20 8/18
	l = 3.00 m	6/20 8/18	6/20 8/18	6/20 8/18	6/24 8/22	6/24 8/22	6/24 8/22
	l = 3.50 m	6/22 8/20	6/24 8/22	6/24 8/22	6/26 8/24	6/26 10/24	8/24 10/24
	l = 4.00 m	6/24 8/24	8/24 8/24	8/24 10/22	8/28 12/24	10/28 12/26	10/28 12/26
	l = 4.50 m	8/26 10/24	8/26 10/24	8/28 10/24	10/30 18/24	10/30 20/24	10/32 20/24

Rafter cross-sections for double span beams

Table 6.5.3 - Rafter cross-sections, C24 (S10), s_k = 0.85 kN/m² for NKL 1 and 2 with medium load durations

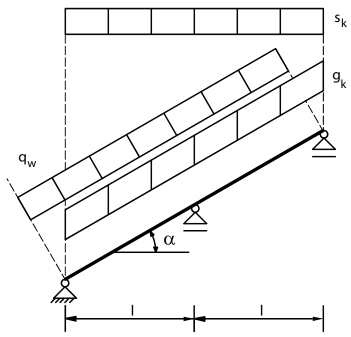
Double span beam - C24 (S10) **g_k = 1.20 kN/m²** **s_k = 0.85 kN/m²** **q_w = 0.90 kN/m²**		**Rafter cross-section b/h [cm]¹⁾** in dependency on roof pitch, rafter spacing e and span l					
		α = 5° - 25°			α = 26° - 35°		
Rafter spacing [m]		0.625	0.75	0.833	0.625	0.75	0.833
Maximum span (area)	l = 2.50 m	**6/10** **8/10**	**6/10** **8/10**	**6/10** **8/10**	**6/10** **8/10**	**6/12** **8/10**	**6/14** **8/10**
	l = 3.00 m	**6/12** **8/10**	**6/12** **8/12**	**6/12** **8/12**	**6/12** **8/12**	**6/14** **8/12**	**6/14** **8/12**
	l = 3.50 m	**6/14** **8/12**	**6/14** **8/14**	**6/14** **8/14**	**6/14** **8/14**	**6/16** **8/14**	**6/16** **8/14**
	l = 4.00 m	**6/16** **8/14**	**6/16** **8/14**	**6/16** **8/16**	**6/16** **8/14**	**6/16** **8/16**	**6/18** **6/16**
	l = 4.50 m	**6/16** **8/16**	**6/18** **8/16**	6/18 **8/16**	**6/18** **8/16**	6/20 **8/18**	6/20 **8/18**
	l = 5.00 m	**6/18** **8/18**	6/20 8/18	**6/20** **8/18**	6/20 **8/18**	**6/22** 8/20	**6/22** **8/20**
Roof pitch		α = 36° - 45°			α = 46° - 55°		
Rafter spacing (m)		0.625	0.75	0.833	0.625	0.75	0.833
Maximum span (area)	l = 2.50 m	**6/12** **8/10**	**6/12** **8/10**	**6/12** **8/12**	**6/14** **8/12**	**6/14** **8/14**	**6/16** **8/14**
	l = 3.00 m	**6/14** **8/12**	**6/14** **8/12**	**6/14** **8/12**	**6/16** **8/16**	**6/18** **8/16**	**6/18** **8/16**
	l = 3.50 m	**6/16** **8/14**	**6/16** **8/14**	**6/16** **8/16**	**6/20** **8/18**	**6/20** **8/18**	6/20 **8/20**
	l = 4.00 m	**6/18** **8/16**	**6/18** **8/16**	6/20 **8/18**	6/22 **8/20**	**6/24** **8/22**	**6/24** 8/22
	l = 4.50 m	6/20 **8/18**	**6/20** **8/18**	**6/22** 8/20	**6/24** 8/22	**8/24** 10/22	**8/24** 10/22
	l = 5.00 m	**6/22** **8/20**	6/22 8/20	**6/24** 8/22	**8/24** 10/22	**10/24** 12/22	**10/24** 12/24



Rafter in the form of a double span beam (identical spans)

Table 6.5.4 - Rafter cross-sections, C24 (S10), s_k = 1.10 kN/m² for NKL 1 and 2 with medium load durations

Double span beam - C24 (S10) **g_k = 1.20 kN/m²** **s_k = 1.10 kN/m²** **q_w = 0.90 kN/m²**		**Rafter cross-section b/h [cm]¹⁾** in dependency on roof pitch, rafter spacing e and span l					
		α = 5° - 25°			α = 26° - 35°		
Rafter spacing [m]		0.625	0.75	0.833	0.625	0.75	0.833
Maximum span (area)	l = 2.50 m	**6/10** **8/10**	**6/10** **8/10**	**6/12** **8/10**	**6/10** **8/10**	**6/12** **8/12**	**6/12** **8/10**
	l = 3.00 m	**6/12** **8/10**	**6/12** **8/12**	**6/14** **8/12**	**6/12** **8/12**	**6/14** **8/12**	**6/14** **8/12**
	l = 3.50 m	**6/14** **8/12**	**6/14** **8/14**	**6/16** **8/14**	**6/14** **8/14**	**6/16** **8/14**	**6/16** **8/14**
	l = 4.00 m	**6/16** **8/14**	**6/16** **8/16**	**6/18** **8/16**	**6/16** **8/16**	**6/18** **8/16**	6/18 **8/16**
	l = 4.50 m	**6/18** **8/16**	6/18 **8/16**	6/20 8/18	**6/18** **8/16**	6/20 **8/18**	**6/20** **8/18**
	l = 5.00 m	6/20 **8/18**	**6/20** **8/18**	**6/22** **8/20**	**6/20** **8/18**	6/22 **8/20**	**6/22** **8/20**
Roof pitch		α = 36° - 45°			α = 46° - 55°		
Rafter spacing (m)		0.625	0.75	0.833	0.625	0.75	0.833
Maximum span (area)	l = 2.50 m	**6/12** **8/10**	**6/12** **8/12**	**6/12** **8/12**	**6/14** **8/12**	**6/14** **8/14**	**6/16** **8/14**
	l = 3.00 m	**6/14** **8/12**	**6/14** **8/14**	**6/14** **8/14**	**6/16** **8/16**	**6/18** **8/16**	**6/18** **8/16**
	l = 3.50 m	**6/16** **8/14**	**6/16** **8/14**	**6/18** **8/16**	**6/20** **8/18**	**6/20** **8/18**	6/20 **8/20**
	l = 4.00 m	**6/18** **8/16**	**6/18** **8/18**	6/20 **8/18**	6/22 **8/20**	**6/24** **8/20**	**6/24** **8/22**
	l = 4.50 m	6/20 **8/18**	**6/22** **8/20**	**6/22** 8/20	**6/24** 8/22	**6/26** 8/24	**6/26** 8/24
	l = 5.00 m	**6/22** 8/20	6/24 **8/22**	**6/24** 8/22	**6/26** 8/24	**6/28** 8/26	**6/30** 8/26



Rafter in the form of a double span beam (identical spans)

7 Tenders

The German contract procedures for building works (VOB/A, Section 9) stipulate the following: "The work required must be described clearly and in sufficient detail to ensure that all bidders understand the description to have the same meaning and to enable them to calculate their prices with certainty and without extensive preparatory work." You can only be certain of obtaining the correct product if the wording in your tender documents is clear, complete and correct in technical terms. Given the high standard of quality to be met by KVH®, Duobalken® and Triobalken®, careful quality controls are required during production. It is therefore in your own interests for you to ensure that the timber you are supplied with comes from quality supervised production sources. For an up-to-date list of supervised firms, please see www.kvh.de. in the internet.

Technical standards

General:

- ATV DIN 18334 - German VOB contract procedures for building works - Part C: General technical specifications for building works for carpentry and timber construction works
- DIN 4074-1 - Strength grading of wood - Part 1: Sawn coniferous timber
- DIN EN 336 - Structural timber – Sizes, permitted deviations
- DIN EN 338 - Structural timber – Strength classes
- DIN EN 1912 - Structural timber – Strength classes – Assignment of visual grades and species

The following applies in addition for

Non-finger-jointed KVH®:

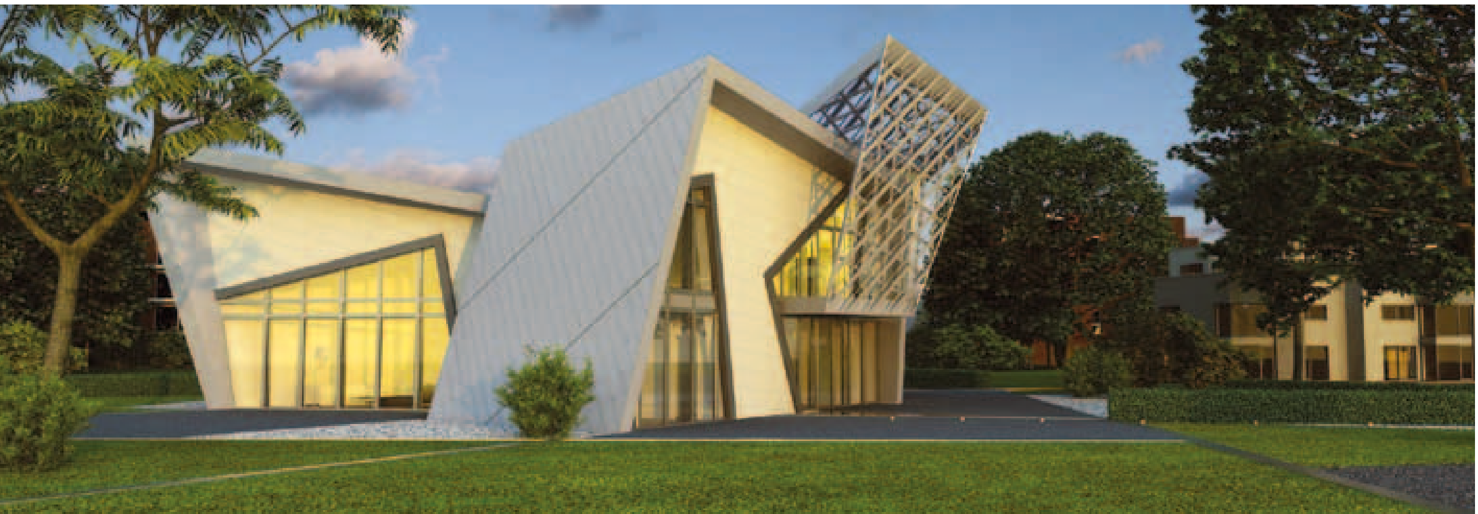
- DIN EN 14081-1 - Timber structures – Strength graded structural timber with rectangular cross section – Part 1: General requirements;
- DIN 20000-5 - Application of construction products in structures – Part 5: Strength graded structural timber with rectangular cross section

Finger-jointed KVH®:

- DIN 1052: 2008-12 - Design of timber structures - General rules and rules for buildings (current version, 2008-12)
- DIN 4074-1 - Strength grading of wood - Part 1: Sawn coniferous timber

Duobalken® and Triobalken®:

- General technical approval of the German building authorities No. Z-9.1-440



Tender wording for the supply of construction timber made of KVH®

Item...: ... m³ Supply of KVH® Si structural finger-jointed timber, S10/C24
KVH® Si (for exposed areas) structural finger-jointed timber compliant with DIN 4074-1 S10TS (strength class C24). Moisture content: u_m = 15 ± 3%. Type of cutting: Split-heart. Surface: Planed and chamfered. Dimensional stability class 2 in accordance with EN 336, from a quality supervised production source.

Item... ... m³ Supply of KVH® NSi structural finger-jointed timber, S10/C24
KVH® NSi (for non-exposed areas) structural finger-jointed timber compliant with DIN 4074-1 S10TS (strength class C24). Moisture content: u_m = 15 ± 3%. Type of cutting: Split-heart. Surface: Leveled and chamfered. Dimensional stability class 2 in accordance with EN 336, from a quality supervised production source.

Tender wording for the supply of glued solid timber

Item... ... m³ Supply of Duobalken® Si glued solid timber, S10/C24
Duobalken® Si (for exposed areas) glued solid timber, made of two planks which are glued together, compliant with DIN 4074-1 S10TS (strength class C24 in accordance with DIN 1052). Moisture content u_m = max. 15%. Surface: Planed and chamfered. Dimensional stability class 2 in accordance with EN 336, from a quality supervised production source, in accordance with approval number Z-9.1-440.

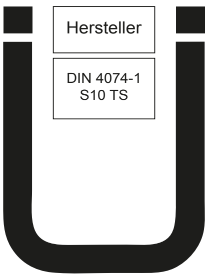
Item... ... m³ Supply of Triobalken® Si glued solid timber, S10/C24
Triobalken® Si (for exposed areas) glued solid timber, made of three planks which are glued together, compliant with DIN 4074-1 S10TS (strength class C24 in accordance with DIN 1052). Moisture content u_m = max. 15 ± 3%. Surface: Planed and chamfered. Dimensional stability class 2 in accordance with EN 336, from a quality supervised production source, in accordance with approval number Z-9.1-440.

Note: Duobalken® and Triobalken® can also be supplied for non-exposed areas, in which case the surface is leveled and the edges are chamfered.

Special requirements

Wood species KVH® structural finger-jointed timber and Duobalken® and Triobalken® glued solid timber are made of spruce/fir as standard. However, they can also be supplied in pine, larch and Douglas fir as well. Where it is intended that the products be used within the terms of Use Class 2 as defined by DIN 68800-1 (temporary humidification, e.g. in protected outside areas) and no preservative treatment is to be used, the tender document must specify sapwood-free dark-colored heartwood of larch or Douglas fir.

8 Quality control and marking



"Ü" mark (inspection mark) and text code for KVH® without finger jointing

zzz	
CE xxx	
Sägewerk xyz. Anschrift 09 xxxxx-CPD-yyyyy	
EN 14081-1	
Bauholz für tragende Zwecke	
C24 (S10)	trocken sortiert
Kurzzeichen für Holzart:	POAB (Fichte)
Sortiernorm:	EN 338 + DIN 4074
Brandverhalten	D-s2.d0
Dauerhaftigkeitsklasse:	4

CE mark of conformity and text code for KVH® without finger jointing

Section 20 of the federal state building regulations in Germany and Section 17 of the German Model Building Regulations (version 11/2002) contain the stipulations governing the use of construction products for the erection, alteration and maintenance of built structures. They require that construction products must bear either the national mark of conformity ("Ü" mark) or the mark of conformity required under the provisions of the Construction Products Law or the Construction Products Directive of the European Community (CE mark of conformity). Building law is violated if solid timber products which do not bear such marks are used for load-bearing structures. The mark provides verification in each case that the product is in compliance with (Ü mark) or conforms with (CE mark of conformity) the technical standards introduced by the building regulation authorities. The mark has to be included on the product or the waybill/packaging. Alternatively it can be applied to the product itself in the form of a text mark. This must specify the manufacturer, the product name, the grading class and the date of production. The "Ü" mark itself or the CE mark of conformity with all information required in addition has to be applied to the waybill. Where considered desirable for reasons of appearance it is permissible to dispense with the application of the mark on the product itself in the case of KVH®-Si structural finger-jointed timber for exposed areas. In this case the respective mark has to appear in full on the delivery note.

Marking of KVH®

KVH® without finger jointing

KVH® without finger-jointed joints can currently be marked with both a German "Ü" mark and the CE mark of conformity. The "Ü" mark relates in this case to DIN 4074-1 as the technical standard with specification of the grading class of the timber. The CE mark of conformity relates to DIN EN 14081-1 as the basis, which, in conjunction with application standard DIN 20000-5, has been introduced by the building regulation authorities by virtue of inclusion in the lists of acknowledged technical rules for works (LTB) of the German federal states.

KVH® with finger jointing

KVH® with finger jointing (the general rule) can currently only be marked with a German ″Ü″ mark on the basis of DIN 1052:2008-12, Annex I. Even if DIN 1052:2008-12 is no longer valid as a dimensioning standard after the introduction EC 5 (DIN 1995-1-1/+NA), it continues to apply as a product standard, e.g. for KVH® with finger jointing. The ″Ü″ mark must therefore include reference to DIN 1052:2008-12, the additional text ″Solid timber with finger-jointed joint″ and the strength class (C24). Also to be included is the symbol or logo of the independent inspection agency responsible for checking that the finger jointing complies with the requirements of DIN EN 385:2007-11.

The members of the Überwachungsgemeinschaft Konstruktionsvollholz e.V. monitor the quality of their products through quality controls within their companies (internal monitoring) and additional monitoring by independent agencies. This applies not just to the mandatory characteristics required under regulations but also to the additional requirements stipulated within the agreement on structural finger-jointed timber. Only structural finger-jointed timber which is monitored in this way and is manufactured by the companies which are members of the Überwachungsgemeinschaft Konstruktionsvollholz e.V. is permitted to bear the internationally protected KVH® trademark.

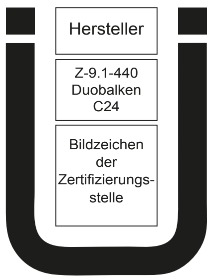
Marking of Duobalken® and Triobalken®

Duobalken® and Triobalken® are not regulated (covered by standards) products. They are approved under building regulations requirements by virtue of certification of suitability for use in the form of product approval number Z-9.1-440 issued by the Deutsche Institut für Bautechnik (DIBt). Z-9.1-440 - Duobalken® and Triobalken® (glued solid timber made of either two or three boards, planks or pieces of square-sawn timber which are glued together). Continuous production controls by the manufacturer (internal monitoring) as well as monitoring by an external agency are mandatory for these products. Compliance with requirements is documented by the German "Ü" mark; there is no provision for marking with a CE mark of conformity to date. The description of the object of approval (Duobalken® or Triobalken®) and the grading class also have to be specified with the ″U″ mark. Where considered desirable for reasons of appearance the timber can be marked with a permanent text code instead of the "Ü" mark. In this case the ″U″ mark has to appear in full on the delivery note.

″Ü″mark (inspection mark) and text code for KVH® with finger jointing

Special characteristics of Duobalken® and Triobalken®

The approval for Duobalken® and Triobalken® beams allows the application of 5% higher values for the modulus of elasticity compared to solid timber. With a value of 11.600 N/mm² it is possible to reduce the amount of deflection, which is a major advantage in relation to a criterion which is often decisive in timber construction. The calculated values for deflection stiffness are therefore the same as those for cross laminated timber of strength class GL24 (previously BS11). All the other strength properties are the same as those for solid timber or KVH®.



″Ü″mark (inspection mark) and text code for Duobalken® and Triobalken®

NOTES

Advantages of KVH® structural finger-jointed timber

- Dried structural timber components available in cross-sections of up to 14/26 cm
- Dimensionally stable because they are kiln-dried to 15 ± 3% and cut on a split-heart basis (free-of-heart on request)
- Two qualities available:
  - planed for exposed areas (Si)
  - leveled for non-exposed areas (NSi)
- Meets higher requirements than those specified in grading standard DIN 4074-1
- • Recommended for structural finger-jointed timber in timber frame buildings and timber house construction
- Minimum tender specification work because of a clear agreement on quality
- Resistant to insects thanks to kiln drying; preservative treatment can be dispensed with
- Economical preferred cross-sections and lengths of up to 13 m available for immediate delivery from stock; longer lengths available on request

Advantages of Duobalken® and Triobalken® beams

- Larger cross-sections of up to 24/28 cm or 10/36 cm available
- Dimensionally stable because they are kiln-dried to a maximum of 15%, cut on a split-heart basis and glued
- Two qualities available:
  - planed for exposed areas (Si)
  - leveled for non-exposed areas (NSi)
- Greater rigidity than solid timber of the same strength class
- Suitable for voluminous or high cross-sections with high requirements in terms of appearance
- Resistant to insects thanks to kiln drying; preservative treatment can be dispensed with
- Economical preferred cross-sections and lengths of up to 13 m available for immediate delivery from stock; longer lengths available on request

Supplied with the compliments of:

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KVH®