Saimaa University of Applied Sciences
Technology, Lappeenranta
Double Degree Programme in Civil and Construction Engineering

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CALCULATION OF KERTO-S FLOOR BEAMS ACCORDING TO RUSSIAN NORMS

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ABSTRACT

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Calculation of Kerto-S floor beams according to Russian norms.
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The company named Finnforest is interested in selling their products on the Russian market.
This is possible due to following reasons:

- The European part of Russia borders to Finland, so the delivery of products doesn't take much time.
- Finland imports approximately 7,5% of Russian raw wooden material, so Finnish companies are known on the Russian market.
- LVL is not widely spread in Russia, so there are no as much competition as in other European countries and USA.

It is problematic that Finnforest calculates their manufacture in compliance with the Eurocode, which is not acceptable in Russia where another regulation is valid. So, as a result of calculation in accordance with Russian SNIPs, two diagrams should be made where maximum span lengths and maximum characteristic loads were represented. Kerto-S was selected as a beam because of its strength, dimensional precision and stability. It is a perfect choice whenever the requirements include minimal deflection. It is also more suitable and economical for floor beams because of variety of lengths and cross sections.

To achieve the final goal (complete diagrams) Mathcad software has been used, and the beams have been calculated according to Russian norms. This program was accepted to meet the company's wishes. During calculations formulas and values from following norms were taken: SNIP # II-25-80 "Timber structures", SNIP #2.01.07-85 "Loads and influences", "Handbook for designing timber structures",standard of organization STO 36554501-002-2006 "Wooden glued and solid timber structures". To draw diagrams Microsoft Excel program was used as a more comfortable variant. The Finnwood 2.3 program, which calculates in conformity with EN 1995-1-1:2004+A1:2008 and National Annex has also been used just for familiarization.

Certainly there are some differences in ideology of calculations according to SNIP and Eurocode (values of loads, factors etc). Therefore, the values of the final diagram differ from those of Finnforest.

CONTENTS

1 INTRODUCTION

Ways of further improving wooden structures are directly related to the development of new production technologies and rational usage of modern material. Laminated veneer lumber is one of these materials. Every year the consumption of such material is growing throughout the world not only in the construction area, but also in the manufacture of furniture, stairs, windows and doors, etc. In Russia, its application is limited because of existing simpler structures and deficiency of investigation about it's physical-mechanical properties.

Finnforest is a wood products company that sells its products on the global market. In Russian market they offer manufacture since 2003. Certainly all calculation were made according to Eurocode. Nowadays it becomes more and more difficult to implement it, because of existing our own norms, which are obligatory for calculating. So to expand their part in Russian market it is necessary to begin calculating in accordance with the Russian norms.

The main purpose of my thesis work is to make diagrams, looking at which Russian contractors will understand what loads and span lengths are suitable for different cross sections of a beam. To fulfill this assignment I calculated a floor beam made of Kerto-S according to the Russian norms. In this thesis the following SNIPs are used: # II-25-80 "Timber structures" and #2.01.07-85 "Loads and influences", and also regulations: "Handbook for designing timber structures" , standard of organization STO 36554501-002-2006 "Wooden glued and solid timber structures". The problem is in almost lack of LVL material in SNIP, so I have used STO 36554501-002-2006, where I found only values for LVL "S-type" which is the same as Kerto-S. It was enough for my thesis, because I calculated floor beams made of Kerto-S.

Mathcad program was offered for calculations according to SNIP. All calculations are found in the appendices. The diagrams were made using the Microsoft Excel program,and they are also in the appendices.

The comparison of the diagrams is also very important. SNIP and Eurocode are the main building norms in the two countries Russia and Finland and they have some differences in the idea of calculation, which has an effect on the results. For instance, in the Russian SNIP # II-25-80 “Timber structures” we don’t pay attention to vibration in residential building floors, but EC5 does. That’s why I received bigger value for beam span length, while calculating according to SNIP. Other results you can find in the appendices.

2 TIMBER COMPOSITES

Wood itself is a natural composite which can be used in its original form or as sawn sections. It can also be converted to particles, strands or laminates which can be combined with other materials such as glues, to form composite wood products. (Trada).

The principal reasons for transforming wood into wood products include:

- to transcend the dimensional limitations of sawn wood
- to improve performance; structural properties, stability or flexibility
- to transform the natural material into a homogenous product
- to utilize low-grade material, minimize waste and maximize the use of a valuable resource. (Ibid).

2.1 Layered composites

Layered composites are high-quality materials. They have a large range of standard dimensions. Glulam and plywood are widely spread all over the world. They have many applications.

2.1.1 Glulam

Glued laminated timber (glulam) is formed by gluing together a series of precision cut small sections of timber to form large cross-section structural members of long length. The timber laminates are strength graded before fabrication. The member can be straight or curved, and can be made with a variable section according to structural requirements. (Trada).

Figure 2.1 Glulam samples (Finnforest).

2.1.2 Plywood

The most familiar sheet laminate is plywood. It comprises thin sheets of wood (veneers) bonded together, most frequently with synthetic glues. The grain of the wood in the different veneers is normally arranged at right angles to each other. (Ibid).

Figure 2.2 Average-quality plywood with show veneer (Wikipedia).

2.2 Particle composites

Particle composites are well known as a basis materials of wooden furniture. Their cost is rather low compared for example to plywood. After treatment procedures particle composites have better physical- mechanical properties and more attractive appearance.

2.2.1 Particle boards

The best-known particle board type is chipboard, made from chips produced by mechanically fracturing wood, such as forest thinners and industrial wood waste, into small fragments. After drying, the graded chips are mixed with resin and formed into boards by curing in a heated press. Cement bonded particleboard comprises small particles of wood bonded with either Portland or magnesite cement, and formed and cured into panels. (Trada).

Figure 2.3 Particle board with veneer. (Wikipedia).

2.2.2 OSB

Oriented strand board (OSB) is made from strands of wood aligned in layers throughout the thickness of the board, the strands having a length of at least twice their width. This produces a cross-ply effect, emulating plywood with similar strength and stiffness. (Ibid).

Figure 2.4 Oriented strand board (temp.krovlja)

2.2.3 Woodwool slabs

Woodwool slabs are made of long strands of wood shavings, tangled, coated in cement and lightly compressed together. They have an open texture, and are very permeable to water vapour and moisture absorbent. (Ibid).

Figure 2.5 Wood wool (Wikipedia).

2.3 Fibre composites

Fibre composites consist of separated fibres. These products are isotropic and flexible. Fibre composites are used for finishing works, furniture manufacturing etc.

2.3.1 Fibreboards

Fibres are produced from chips of wood (mainly from forest thinners), which are reduced to a pulp by mechanical or pressure heating methods. The pulp is mixed with water and other additives, formed on a flat surface and pressed at high temperature. In most fibreboards the basic strength and adhesion is obtained from the felting together of the fibres themselves and from their own inherent adhesive properties. There are three basic types of boards, differentiated by their increasing density; insulation board, Medium board and hardboard. (Trada).

2.3.2 MDF

Medium density fibreboard (MDF) differs from the others in that it is manufactured by a dry process using resin glue. The homogeneous cross section and smooth faces of MDF give high quality surfaces that are ideal for painting. (Ibid).

Figure 2.6 A sample of MDF (Wikipedia).

2.4 Structural timber composites and structural assemblies

Structural timber composites have the advantage of being manufactured at low moisture contents, thereby minimizing shrinkage in heated buildings. Their properties are consistent and they are typically stronger and longer spanning than solid timber sections. (Ibid).

2.4.1 Laminated veneer lumber

Laminated veneer lumber is produced by bonding together veneers peeled from a log, in much the same way as plywood is manufactured, and then cutting the resulting long panels into structural sized sections. Unlike plywood, successive veneers are generally orientated in a common grain direction. (research.ttlchiltern according to Mettem, Gordon ,Bedding 1996).

Figure 2.7 Laminated veneer lumber (research.ttlchiltern according to Mettem, Gordon ,Bedding 1996).

2.4.2 Parallel strand lumber

Parallel strand lumber is manufactured by cutting peeled veneers into long strands which are coated with adhesive and combined under heat and pressure in a quasi-extrusion process to form structural- sized sections in long lengths. PSL uses veneers with more defects in a more random-looking pattern . (Ibid).

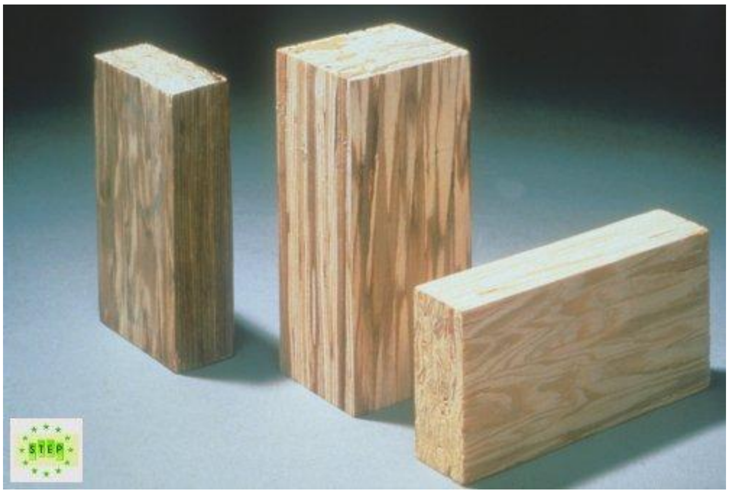


Figure 2.8 Parallel strand lumber (Ibid).

2.4.3 Laminated strand lumber

Laminated strand lumber is produced by bonding together large flakes of wood, again under heat and pressure, to produce structural sections. LSL uses smaller veneers, and so is similar to oriented strand board (OSB) in appearance. (Ibid).

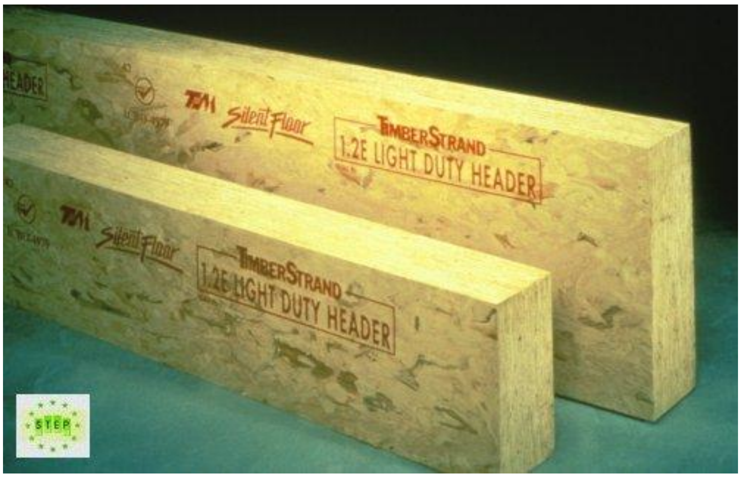


Figure 2.9 Laminated strand lumber (Ibid).

2.4.4 I-beams

More complex structural assemblies can be built up using solid timber and wood composites to increase stiffness and strength. Prefabricated I-beams, manufactured with solid timber or LVL flanges and wood-based panel webs are now widely available and are increasingly popular. (Trada)

Figure 2.10 I joist (Trada).

3 KERTO

Kerto is a laminated veneer lumber (LVL) product used in all kinds of construction jobs, from new buildings to renovation and repair. It is used in a variety of applications including beams, joists, trusses, frames, components of roof, floor and wall elements, components of door and vehicle industry, concrete formwork and scaffold planking. (Finnforest).

Kerto is a strong and dimensionally stable product which does not warp or twist. It derives its high strength from the homogeneous bonded structure which also keeps the effects of any defective single veneers down to a minimum. (Ibid).

3.1 Kerto's milestones

Figure 3.1 Punkaharju mill (Finnforest).

1973 Start-up of the Metsäliitto LVL project

1975 Start-up of the Kerto LVL pilot plant in Punkaharju, Finland

1975 – 2001 Matti Kairi acted as a key person who contributed to the development, production and marketing of Kerto

1978 First type approval of Kerto in Finland

1981 First type approval of Kerto in Scandinavia and Germany

Start-up of Kerto production on a commercial scale in Lohja,Finland

1982 First product acceptance in the French and US markets. In the US the product is named Master Plank

1982 Breakthrough in Finland

1984 Breakthrough in the USA

1986	Start-up of the second Kerto production line in Lohja, Finland
1991	Type approval of Kerto for structural panels in Germany
1992	Breakthrough in Germany
1996	Breakthrough in France
1998	Start-up of the third Kerto production line in Lohja, Finland
2001	Start-up of the second Kerto mill in Punkaharju, Finland
2005	Start-up of the second Kerto production line in Punkaharju, Finland

Nowadays Kerto production in Lohja is 200 thousand cubic metres per year, and the company employs 200 people. Half of the production is exported to Europe and U.S., a quarter stays in Finland. The material is widely used in construction. In 1996 the first multistorey house made of Kerto was built. (Finnforest).

3.2 Manufacturing process

Logs are debarked and soaked in hot water for 24 hours. They are then rotary peeled to produce veneers, typically 3 -4 mm thick which are clipped into sheets about 2 m wide. After drying, phenol formaldehyde adhesive is applied to the veneers, which are normally laid with the grain running parallel, to form a continuous mat of the desired thickness.

Joints are staggered vertically to minimize their effect on the strength of the LVL. The mat is pressed at a temperature of about 150 °C. After pressing, each sheet of LVL is cross-cut and rip-sawn to produce sections of the required dimensions.

The finished LVL may have glue splashes on the faces and will have square edges that can be damaged in handling. Where LVL is to be exposed, the edges should be rounded, the faces sanded and given 1-2 coats of the chosen finish before delivery to site. (research.ttlchiltern according to Mettem, Gordon ,Bedding 1996).

Figure 3.2 Kerto further processing (Finnforest).

3.3 Kerto S

A notable feature of Kerto-S is that the grains run longitudinally throughout its veneer layers. The finished panel is cross-cut and rip-sawn to order. Kerto-S is normally supplied in the form of straight beams but it may also be cut to required shapes. (Finnforest).

Kerto-S unites excellent technical performance with ease of use. Strength, dimensional precision and stability are the essential qualities of Kerto-S. In fact, as beams it is a perfect choice whenever the requirements include long spans and minimal deflection. They fit in with all roof shapes, also performing well as joists and lintels, intrussed constructions and frames. Kerto-S is also a much-used material in the manufacture of prefabricated components. (Ibid).

Kerto's light weight is of great advantage especially during building repairs. The erection work can be carried out by fitters, without any heavy hoisting machinery, even in confined spaces. Kerto-S can be coated, to blend in with the rest of the architecture thus making a harmonious whole. (Ibid).

Thickness (mm)	Height (mm)								
	200	225	260	300	360	400	450	500	600
27	•	•							
33	•	•	•						
39	•	•	•	•					
45	•	•	•	•	•				
51	•	•	•	•	•	•			
57	•	•	•	•	•	•	•		
63	•	•	•	•	•	•	•	•	
75	•	•	•	•	•	•	•	•	•

Figure 3.3 Kerto-S dimensions (Finnforest).

3.4 Kerto Q

Kerto-Q is cross-bonded Kerto. This means that one-fifth of the veneers are glued crosswise. This structure improves the lateral bending strength and stiffness of the panel, thus increasing the shear strength when used as a beam. With cross-bonded veneers, there is an essential reduction in moisture-dependent variations across the width of the panel.(Ibid).

Kerto-Q comes in the same dimensions and lengths as Kerto-S, except that its maximum thickness is 69 mm. Full-length Kerto-Q is a popular material in floor and wall panels, because it stabilizes the whole structure, and a good fire resistance is achieved with a properly chosen thickness. Kerto-Q panels are also appreciated for their natural beauty, now that ecological considerations carry special weight. (Ibid).

Kerto-Q provides a functional solution in structural components, also when a high shear strength is one of the requirements. Like all Kerto products, also Kerto-Q is known for its strength, straightness and dimensional stability.(Ibid).

Kerto-Q is available with the same standard widths as Kerto-S. Additionally, the following widths are available.

Thickness (mm)	Width (mm)					
	900	1200	1800	2500	1800	2500
27	•	•	•	•	•	•
33	•	•	•	•	•	•
39	•	•	•	•	•	•
45	•	•	•	•	•	•
51	•	•	•	•	•	•
57	•	•	•	•	•	•
63	•	•	•	•	•	•
69	•	•	•	•	•	•
75	•	•	•	•	•	•
78	•	•	•	•	•	•

Figure 3.4 Kerto-Q (Ibid).

3.5 Kerto T

Kerto-T is just like Kerto-S, but made from lighter veneers. Nevertheless, its straightness and dimensional stability are as good as with Kerto-S. This makes it ideal for studs to be used as load-bearing and non-bearing structures in external and internall walls. (Ibid).

It is easy to construct high walls, which can be counted on remaining straight. Kerto-T can be used with any sheet materials that are easily fixed without special tools. (Ibid).

Thickness	mainly 39-45 mm
Width	mainly < 200 mm
Length	mainly < 8.5 mm

Figure 3.5 Kerto-T (Ibid).

3.6 Flooring solutions

3.6.1 Beams

Beams are the widest spread floor type. They afford to choose your own floor structure: will it contain insulation or not, what type of insulation will be used, what will be the beam's cross section, step, what will be as covering material etc, so you are not limited to prefabricated floor structure dimensions. Application of beams allows to model the floor structure in accordance with your wishes.

3.6.2 Kerto-Ripa panel

The Kerto-Ripa panel is a structural engineered timber building element made from glued Kerto members. It is used to create the ground, intermediate floors and roofs of residential, commercial and public buildings. Kerto-Ripa can be used in both thermo-insulated structures and non-insulated structures. (Finnforest).

Figure 3.6 Sample of Kerto-Ripa panel (Finnforest).

Advantages:

- Fast installation - up to 1000m2 of weather protection in one day
- Reduces the need for protective covering during construction at the building site
- Pre-fabrication ensures even quality
- Reduces turnaround time for construction projects
- Carefully-timed delivery for the building phase
- Clear, long spans
- Environmentally sound

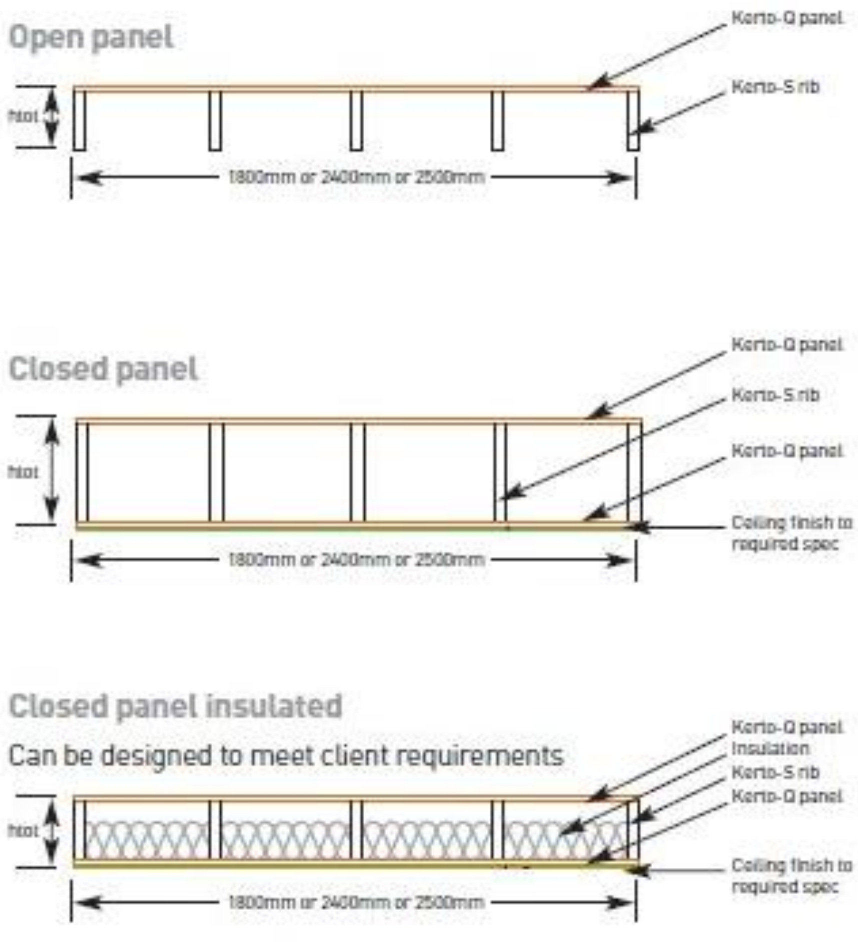


Figure 3.7 Variants of Kerto-Ripa panel (Finnforest).

3.6.3 I-beams

Finnjoists (FJI) are manufactured from high quality OSB3 web, and flanges made from Kerto ® (LVL), delivering less dimensional change over time, virtually eradicating floor movement and its associated problems, resulting in greater floor performance. (Finnforest).

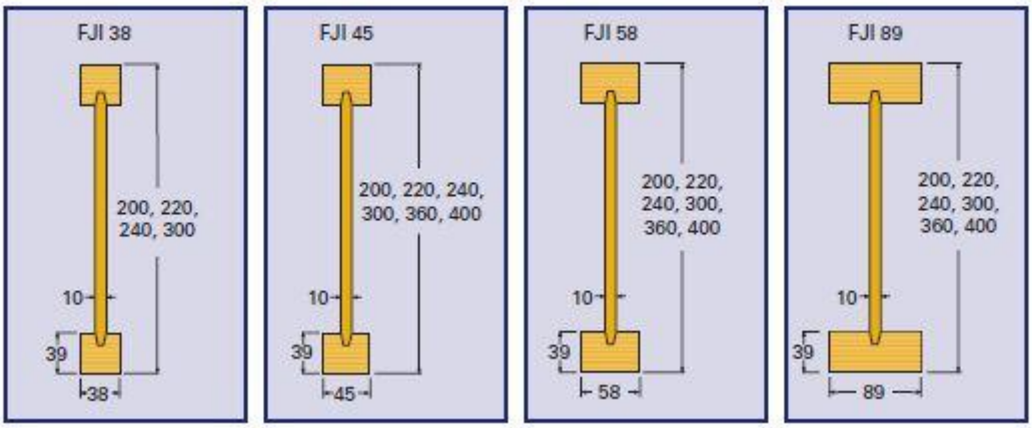


Figure 3.8 Standard Finnjoist sizes (Finnforest).

I-beams have good strength properties such as excellent bearing capacity, and they are more economical because of less material consumption and OSB usage, which is cheaper than Kerto.

Figure 3.9 Example of flooring system with Finnjoists. (Finnforest).

4 CALCULATIONS ACCORDING TO RUSSIAN NORMS

During the calculations the following regulations were used: # II-25-80 “Timber structures” , #2.01.07-85 “Loads and influences” , “Handbook for designing timber structures” , standard of organization STO 36554501-002-2006 Wooden glued and solid timber structures”. In Russia we have the same limit state design ideology as in Europe.

4.1 Collecting of loads

The first step is collecting loads. Live load (the only uniformly distributed load for floor beam) and dead load- self weight have an effect on the structure described here.

I chose a live load p_1= 1.5 kN/m^2 in accordance with the Russian norms specifically from table 3 SNIP #2.01.07-85 “Loads and influences” (attached in Appendix 1). In my situation the value should be 1.5 kN/m^2 for flats in residential houses. Old Finnish design instruction had the same value but nowadays it’s changed to 2.0 kN/m^2.

The chosen value should be multiplied with service factor γ_f to get a design value from the characteristic value. Russian regulations say that γ_{f1} =1.3 should be accepted if the characteristic value of uniformly distributed load less than 2.0 kN/m^2 and γ_{f1}=1.2 if it’s 2.0 kN/m^2 and more. I accepted γ_{f1}=1.3.

The characteristic value of self weight is according to Kerto brochure p_2=0.6 kN/m^2. It includes beam weight, insulation weight, cover structure weight, weight of partition wall. Service factor γ_{f2}=1.1 for timber constructions (table 1 SNIP #2.01.07-85 “Loads and influences”, attached in appendix 2).

So the characteristic value of full load :

$$q_c=(p_1+p_2)\cdot k \qquad (4.1)$$

k- step (distance between beams), m

Design value:

$$q_d=(p_1\cdot \gamma_{f1}+ p_2\cdot \gamma_{f2}) \cdot k \qquad (4.2)$$

4.2 Ultimate limit state design

4.2.1 Bending

The floor beam bends, for this case SNIP offers a formula which should be satisfying (SNIP # II-25-80 “Timber structures” , formula # 17) :

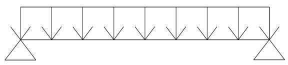
$$\frac{M}{W_{расч}} \le R_u \qquad (4.3)$$

M- bending moment, kNm

$W_{расч}$- resisting moment, m^3

R_u- bending strength, kN/m^2

$$M = \frac{q_d \cdot l^2}{8} \qquad (4.4)$$



l- span length, m

$$W_{расч} = \frac{b \cdot h^2}{6} \qquad (4.5)$$

b- thickness of beam, m

h- height of beam, m

In Russian norms we already have a design value in tables, comparing with Eurocode system, where tables contain only characteristic resistances, so I have used design resistances from STO 36554501-002-2006 “Wooden glued and solid timber structures”.

This design value should be multiplied with the following service factors:
m_v – service factor, which depends on service conditions. Table with values both from SNIP and Eurocode you can find in “CTO 36554501-002-2006” (attached in appendix 4). I adopted C2 class according to Eurocode which is equal to A3 class according to SNIP # II-25-80 “Timber structures”. This is the least favourable situation from two possible variants:C1 and C2 classes, because it has a bigger value of relative humidity, so that it will be less comfortable for living.

Table 5 in SNIP # II-25-80 “Timber structures” (attached in appendix 5) represent the coefficients that comply with the above mentioned service classes. In my occasion m_v=0.9.

γ_n- safety factor. According to STO 36554501-002-2006 “Wooden glued and solid timber structures”, table 9a all buildings are classified in one of three levels of reliability: I- increased , II-normal , III-decreased.

The first level should be accepted for buildings, the collapse of which can cause serious economical, ecological and social consequences for example containers with oil, pipelines, industrial buildings with a span length of 100 m, and also unique buildings.
The second level is suitable for common buildings for instance residential, industrial, agricultural. The decreased level is possible only for temporary buildings, for example greenhouses, summer kiosks. So, the correct level for my study is the second one, because it concerns a family house.

Safety factor γ_n =1 for a building with a second level of service conditions (see Appendix 3)

Finally, the bending strength will read as follows:

$$R_u = \frac{R_d \cdot m_v}{\gamma_n} \qquad (4.7)$$

To create the first diagram I expressed the span length value as *l* from formula (4.3), and took values from formula (4.4):

$$\frac{q_d \cdot l^2}{8 \cdot W_{расч}} = R_и \qquad (4.10)$$

$$l = \sqrt{\frac{8 \cdot R_и \cdot W_{расч}}{q_d}} \qquad (4.11)$$

This way I got the *l* value from shear, deflection, vibration and bearing calculations, compared them and accepted the minimum value of the span length each cross section may have.

The second diagram represents the dependence between loads and span lengths of beams of various cross section. The distances between supports are given, so it is not needed to calculate them as for the first diagram. To find the characteristic load values, I expressed q_d from formula (4.10).

$$q_d = \frac{8 \cdot W_{расч} \cdot R_и}{l^2} \qquad (4.12)$$

I received a design value of full load. After deflection calculation I got characteristic value. To compare the results I transformed the design value to the characteristic. Self weight percentage is 20%, so live load has 80% or IOW dead load has one part and live load has 4 parts.

$$q_d = 4 \cdot p \cdot \gamma_{f_1} + p \cdot \gamma_{f_2} \qquad (4.13)$$

p- self weight, kN/m^2

4p- live load, kN/m^2

γ_{f1}, γ_{f2} - service factor from clause 4.1

$$q_c = 4 \cdot p + p \qquad (4.14)$$

4.2.2 Shear

The following expression should be satisfied in accordance with SNIP # II-25-80 “Timber structures”:

$$\frac{QS'_{бр}}{I_{бр}b_{расч}} \leq R_{ск} \qquad (4.15)$$

Q (V in Eurocode)- shear force, kN

$S'_{бр}$- first moment, m^3

$I_{бр}$ –moment of inertia, m^4

$b_{расч}$=b- thickness of beam,m

$R_{ск}$- shear strength, kN/m^2

$$Q = \frac{q_d \cdot l}{2} \qquad (4.16)$$

$$S'_{бр} = \frac{b \cdot h^2}{6} \qquad (4.17)$$

$$S'_{бр} = \frac{A \cdot h}{2 \cdot 4} = \frac{b \cdot h \cdot h}{2 \cdot 4} = \frac{b \cdot h^2}{6} \qquad (4.18)$$

simple formula for ½ cross section

A- area, m^2

$$I_{бр} = \frac{b \cdot h^3}{12} \qquad (4.19)$$

for rectangular cross section

To get a $R_{ск}$, R_d should be multiplied with the same factor m_v and divided with γ_n , as in clause 4.2.1.

4.2.3 Lateral buckling

To prevent a collapse lateral buckling calculations should be made for bending structures. In this study the floor structure is protected against lateral buckling by fastening the floor slabs to beams, therefore, there is no need for calculating lateral buckling.

4.3 Serviceability limit state design

4.3.1 Deflection

Vibration calculation in accordance with SNIP is rather different than in Eurocode. We don't distinguish instantaneous deflection and creep deflection, and the limiting values are also different.

While calculating in conformity with Russian SNIP #2.01.07-85 "Loads and influences" the following expression should be satisfiying:

$$f \leq f_u \qquad (4.20)$$

f- calculated deflection

f_u- limiting value for deflection, *l*/250 according to table 16, SNIP # II-25-80 "Timber Structures" (attached in appendix 6).

According to SNIP # II-25-80 "Timber Structures":

$$f = \frac{f_0}{k}\left[1 + c\left(\frac{h}{l}\right)^2\right] \qquad (4.21)$$

f_0- deflection of the beam, without including shear deflection.

k-factor ,which pays attention to the variability of cross section, for constant cross section k=1

c-coefficient ,which includes shear deflection should be calculated with help of SNIP # II-25-80 "Timber Structures",appendix 4,table 3 (attached in appendix 7)

General mechanics formula for pinned supported beam:

$$f_0 = \frac{5 \cdot q_n \cdot l^4 \cdot \gamma_n}{384 \cdot E \cdot I} \qquad (4.22)$$

q_n- characteristic value of full load, kN/m

γ_n- safety factor, same as in clause 6.2.1

E- value of modulus of elasticity. In SNIP # II-25-80 “Timber Structures” this value is E = 10000 MПa parallel to the grain, E_{90} = 400 MПa perpendicular to the grain, edgewise.

I- moment of inertia, m^4,same as in (4.19)

4.3.2 Vibration

The Russian way of calculation doesn’t pay any attention to vibration, so it was decided to calculate vibration according to EC5 and National Annex. There are some differences between EC5 and National Annex.

1) For residential floors with a fundamental frequency less than 8Hz ($f_1 \leq$ 8Hz) a special investigation should be made.

2) For residential floors with a fundamental frequency greater than 8 Hz (f_1 > 8 Hz) the following requirements should be met:

$$\frac{w}{F} \leq a \ \text{mm/kN} \qquad (4.23)$$

$$v \leq b^{(f_1 \cdot \zeta - 1)} \ \text{m/(Ns}^2) \qquad (4.24)$$

where:

w is the maximum instantaneous vertical deflection caused by a vertical concentrated static force *F* applied at any point on the floor, taking the load distribution into account;

v is the unit impulse velocity response, i.e. the maximum initial value of the vertical floor vibration velocity (in m/s) caused by an ideal unit impulse (1 Ns) applied at the point of the floor giving maximum response. Components above 40 Hz may be disregarded;

ζ is the modal damping ratio. (Eurocode 5).

NOTE: The recommended range of limiting values of *a* and *b* and the recommended relationship between *a* and *b* is given in Figure 7.2. Information on the National choice may be found in the National annex. (Ibid).

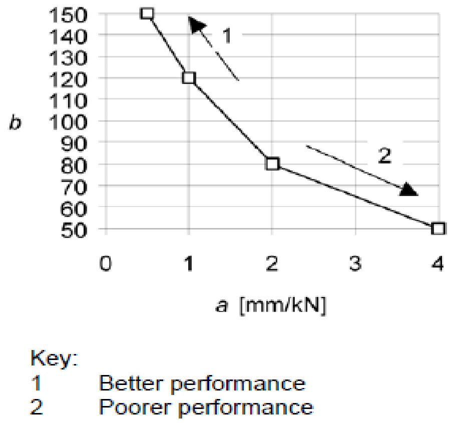


Figure 4.1 Recommended range of and relationship between a and b. (EC 5, Figure 7.2).

3) The calculations, if f_1>8 Hz should be made under the assumption that the floor is unloaded, i.e., only the mass corresponding to the dead load of the floor and other permanent actions. (Ibid).

4) For a rectangular floor with overall dimensions *l* × *b*, simply supported along all four edges and with timber beams having a span *l*, the fundamental frequency f_1 may approximately be calculated as:

$$f_1 = \frac{\pi}{2 \cdot l^2}\sqrt{\frac{(E \cdot I)_l}{m}} \qquad (4.25)$$

where:

m is the mass per unit area in kg/m²;

l is the floor span, in m;

$(EI)_l$ is the equivalent plate bending stiffness of the floor about an axis perpendicular to the beam direction, in Nm²/m.

(5) For a rectangular floor with overall dimensions *b*×*l* , simply supported along all four edges, the value *v* may, as an approximation, be taken as:

$$v = \frac{4 \cdot (0.4 + 0.6 \cdot n_{40})}{m \cdot b \cdot l + 200} \qquad (4.26)$$

where:

v is the unit impulse velocity response, in m/(Ns^2)

n_{40} is the number of first-order modes with natural frequencies up to 40 Hz;

b is the floor width, in m;

m is the mass, in kg/m^2

l is the floor span, in m.

The value of n_{40} may be calculated from:

$$n_{40} = \left\{ \left(\left(\frac{40}{f_1} \right)^2 - 1 \right) \left(\frac{b}{l} \right)^4 \frac{(EI)_l}{(EI)_b} \right\}^{0.25} \qquad (4.27)$$

where $(EI)_b$ is the equivalent plate bending stiffness, in Nm^2/m, of the floor about an axis parallel to the beams, where $(EI)_b < (EI)_l$. (Ibid).

National Annex has 9 Hz as the limiting value. The fundamental frequency should exceed this value to meet the requirements.

For a square room with a side of 6m and more, *a* value is 0.5 mm/kN. If the side is shorter than 6 m, *a* value will be something else.

4.3.3 Bearing

The force, that has an effect on the connection (the floor beam joined with the wall structure) should not exceed the design bearing capacity of this connection (according to SNIP # II-25-80 “Timber Structures”).

$$R \leq T \qquad (4.28)$$

T- design bearing capacity, kN

R- support reaction, KN

$$R=Q \qquad (4.29)$$

Q- shear force, kN, calculated as in clause 4.2.2

$$T = R_{sm} \cdot F_{sm} \qquad (4.30)$$

F_{sm}- bearing stress area, m^2

R_{sm}- bearing resistance, kN/m^2

$$F_{sm} = a \cdot b \qquad (4.31)$$

a- width of support (according to Kerto brochure)

b- width of beam, mm

To receive a value for bearing resistance, design value should be multiplied by factor m_v and divided by γ_n like in clause 4.2.1.

5 CONCLUSION

I have made calculations of Finnforest Kerto-S floor beam according to Russian standards. The result (diagrams) are different when they are calculated according to Eurocode. It occurred, first of all, because of differences in details of calculation between SNIP and the European standards. The main idea is the same limit state design, when values of live load, limiting values for deflection, values of modulus of elasticity and other values vary.

For the first diagram maximum span lengths were calculated according to Russian norms. They are quite much bigger than spans calculated in accordance with the Eurocode 5 and Finnish National Annex. It can be explained by lack of vibration calculation in the Russian SNIP. That's why I made a complex calculation (vibration was calculated according to Eurocode and the other part in accordance with SNIP). In this case the results are almost equal. Table 5.1 shows span lengths, first column display beam cross sections, the second and third contain information about span lengths as a result of deflection calculations, because this calculations provide the least value. The distance between beam in the second column is k=0.6 m and in third k=0.4 m. The fourth and fifth columns represent values received from vibration calculation. The fourth comprises to non glued structures and the fifth glued ones.

Table 5.2 shows spans, calculated according to Eurocode. The first column for non glued structure, the second for glued.

Table 5.1 maximum span lengths according to Russian norms in mm.

cross-section	k=0,6 m without vibration	k=0.4 m without vibration	k=0.4 with vibration non glued	k=0.4 with vibration glued
45x200	3,91	4,47	3,60	3,80
51x200	4,07	4,65	3,70	3,90
45x260	5,06	5,78	4,60	4,90
45x300	5,83	6,65	5,30	5,50
51x300	6,07	6,92	5,50	5,70
45x360	6,98	7,94	6,20	6,40
51x400	8,05	9,15	6,90	7,10

Table 5.2 maximum span lengths according to Eurocode 5 and Finnish National Annex in mm.

cross section	non glued	glued
45x200	3,4	3,7
51x200	3,7	3,8
45x260	4,5	4,7
45x300	5,2	5,5
51x300	5,3	5,6
45x360	6	6,5
51x400	7	7,3

The second diagram has two requirements differing from the previous one: this case provides calculation of the main beam (not secondary as in the first diagram) and in Kerto brochure it is said that the share of self-weight is 20 %. I realized that the difference in results is not so significant. The main reason why it is so could be explained by lack of vibration calculation in Eurocode main beam design.

The columns in Table 5.2 show maximum characteristic loads, when the span length is 2m, 2,5m, 3m etc. The same characteristics were represented in Table 5.3, but the calculations were based on Eurocode 5 and Finnish National Annex.

Table 5.3 maximum characteristic loads according to Russian norms.

cross section mm/span length m	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
51x200	10,373	6,639	4,61	3,387	2,593	2,049	1,66	1,372	1,153
45x260	14,873	9,899	6,875	5,051	3,867	1,006	2,475	2,045	1,719
45x300	17,161	13,18	9,153	6,724	5,148	1,013	3,295	2,723	2,288
51x300	19,449	14,937	10,373	7,621	5,835	0,542	3,734	3,086	2,593
45x360	20,593	16,475	13,18	9,683	7,414	1,248	4,745	3,921	3,295
51x400	25,932	20,746	17,288	13,548	10,373	2,338	6,639	5,486	4,61

Table 5.4 maximum characteristic loads according to Eurocode 5 and Finnish National Annex.

cross section mm/span length m	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
51x200	9,1	4,9	3,8	2,7	1,3	0,8	0,6	0,4	0,3
45x260	14,8	9,8	5,4	3,5	2,4	1,8	1,2	0,9	0,7
45x300	17,2	12,8	8	5,3	3,6	2,7	1,9	1,4	1,1
51x300	19,4	14,5	9	6	4,1	2,9	2,2	1,6	1,3
45x360	20,6	16,3	12,8	8,6	6	4,3	3,2	2,5	1,9
51x400	25,9	20,7	17,3	12,8	9,1	6,7	5	3,8	2,9

Resulting diagrams are attached in Appendix 8 and 9.

FIGURES

TABLES

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APPENDICES

APPENDIX 1

Characteristic values of uniformly distributed loads for floor structures and stairs.

Buildings and premises	Characteristic value of load p ,kPa	
	full	decreased
1.Flats in residental houses; sleeping rooms in kindergartens; living rooms in rest houses, hotels; wards in hospitals; terraces.	1,5	0,3
2.Working spaces in offices; classrooms in educational institutions; sanitary facilities (cloakrooms, showers, WC) in industrial buildings.	2,0	0,7
3.Offices and laboratories in medical institutions; laboratories in educational and science institutions; computer premises; technical floors; basements.	2,0 and more	1,0 and more
4.Halls:		
a) reading rooms	2,0	0,7
b) dining (in cafes and restaurants)	3,0	1,0
c) meeting, waiting, concert, sport	4,0	1,4
d) sales, exhibition	4,0 and more	1,4 and more

Buildings and premises	Characteristic value of load p ,kPa	
	full	decreased
5.Libraries; archives	5,0 and more	5,0 and more
6.Scenes	5,0 and more	1,8 and more
7.Tribunes:		
a) with fixed chairs	4,0	1,4
b) for staying	5,0	1,8
9.Roof structures in the following areas:		
a)people concentration areas (going outside from halls, auditoriums)	4,0	1,4
b) using for rest	1,5	0,5
c) other	0,5	-
10.Balconies, including loads:		
a)distributed on area with the width of 0,8 м along the balcony barrier	4,0	1,4
b) distributed on the balcony area. Its influence more harmful than in clause 10 a)	2,0	0,7

Buildings and premises	Characteristic value of load p ,kPa	
	full	decreased
11.Service and equipment repairing areas in industrial premises	1,5 and more	-
12.Vestibules, foyers, corridors, stairs, adjoined to rooms, mentioned in clauses:		
a) 1, 2 и 3	3,0	1,0
b) 4, 5, 6 и 11	4,0	1,4
c) 7	5,0	1,8
13.Railway platforms	4,0	1,4
14.Premises for cattle:		
small	2,0 and more	0,7 and more
big	5,0 and more	1,8 and more

Service factors for different types of structures and soils.

Types of structures and soils	Service factor γ_f
Structures:	
metal	1,05
concrete (with a general density more than 1600 кг/ $м^3$), reinforced concrete, stone, timber	1,1
concrete (with a general density of 1600 кг/ $м^3$ and less), insulating, finishing layers (slabs, rolled materials, cement covering), fabricating:	
prefabricated	1,2
on a building site	1,3
Soils:	
natural	1,1
filled-up soil	1,15

Values of γ_n factor for various reliabiilty classes of buildings.

reliability levels	application	examples	factor γ_n
I- increased	important buildings, collapse of which can cause serious economical and social consequences	containers with oil, pipelines, industrial buildings with 100 m span length, unique buildings	1.05
II-normal	wide spread and massively built buildings	residental, industrial, agricultural buildings	1
III-decreased	seasonable and temporary buildings	greenhouses, summer kiosk, small storages	0.9

APPENDIX 4

Service classes

Service classes	Description of service conditions	Maximum relative humidity, %	
		Glued timber	Non glued
	Inside heated places with a temperature of 35 °C and less, and relative humidity, %:		
$\left.\begin{matrix}A1\\A2\end{matrix}\right\}(C1)$	60 and less	9	20
	from 60 to 75	12	20
А3 (С2)	from 75 to95	15	20
	Inside not heated spaces:		
$\left.\begin{matrix}Б1\\Б2\end{matrix}\right\}(C3)$	In dry zone	9	20
	In normal zone	12	20
Б3 (С3.1)	In dry and normal zones with constant inside humidity more than 75 % and in wet zone	15	25
	In open air:		
$\left.\begin{matrix}B1\\B2\\B3\end{matrix}\right\}(C3.2)$	In dry zone	9	20
	In normal zone	12	20
	In wet zone	15	25
	In parts of building:		
Г1 (С4)	Adjoined to soil or situated in soil	-	25
Г2 (С4.1, С4.2)	Permanently wet	-	Not limited
Г3	Located in water	-	Also

Values of service factor m_v

Service classes	Factor m_v	Service classes	Factor m_v
А1, А2, Б1, Б2	1	В2, В3, Г1	0,85
А3, Б3, В1	0,9	Г2, Г3	0,75

Limiting values for deflection

Structures	Limiting values for deflection
1. Floor beams	1/250
2. Camp celling beams	1/200
3. Roof system (except valley):	
а)girder, rafter	1/200
б)cantilever beams	1/150
в)trusses, glued beam (except cantilever)	1/300
г) slabs	1/250
д) lathing, covering	1/150
4. Bearing valley elements	1/400
5. Panels and elements of timber framing	1/250

Values of k and c factors for different cross sections and loads location.

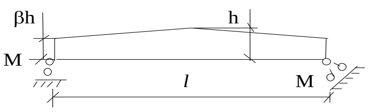
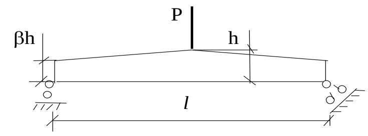
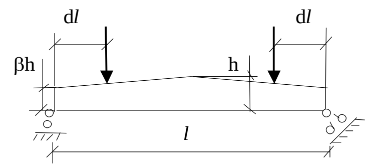
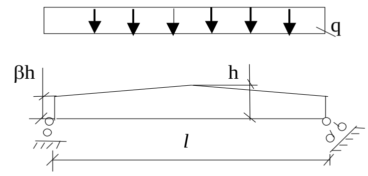
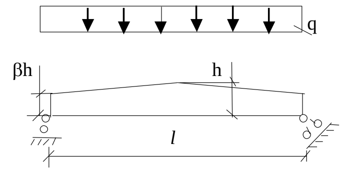
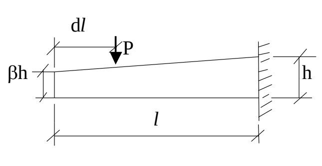
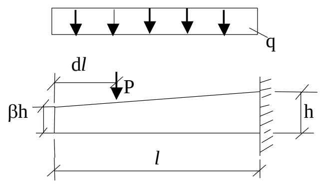
Cross section	Scheme	k	c
Rectangular		β	0
The same		0,23 + 0,77β	16,4 + 7,6β
The same		0,5d + (1 - 0,5d) β	[45 - 24d(1 - β) + 3β] × $\frac{1}{3-4d^2}$
The same		0,15 + 0,85β	15,4 +3,8β
I-section		0,4 + 0,6β	(45,3 - 6,9β)γ
Rectangular		0,23 + 0,77β + 0,6d(1 - β)	[8,2 + 2,4(1 - β)d + 3,8β × $\frac{1}{(2+a)(1-a)}$
The same		0,35 + 0,65β	5,4 + 2,6β

Diagram representing maximum span lengths of a floor beam, calculated according to Russian norms, Eurocode 5 and Finnish National Annex.

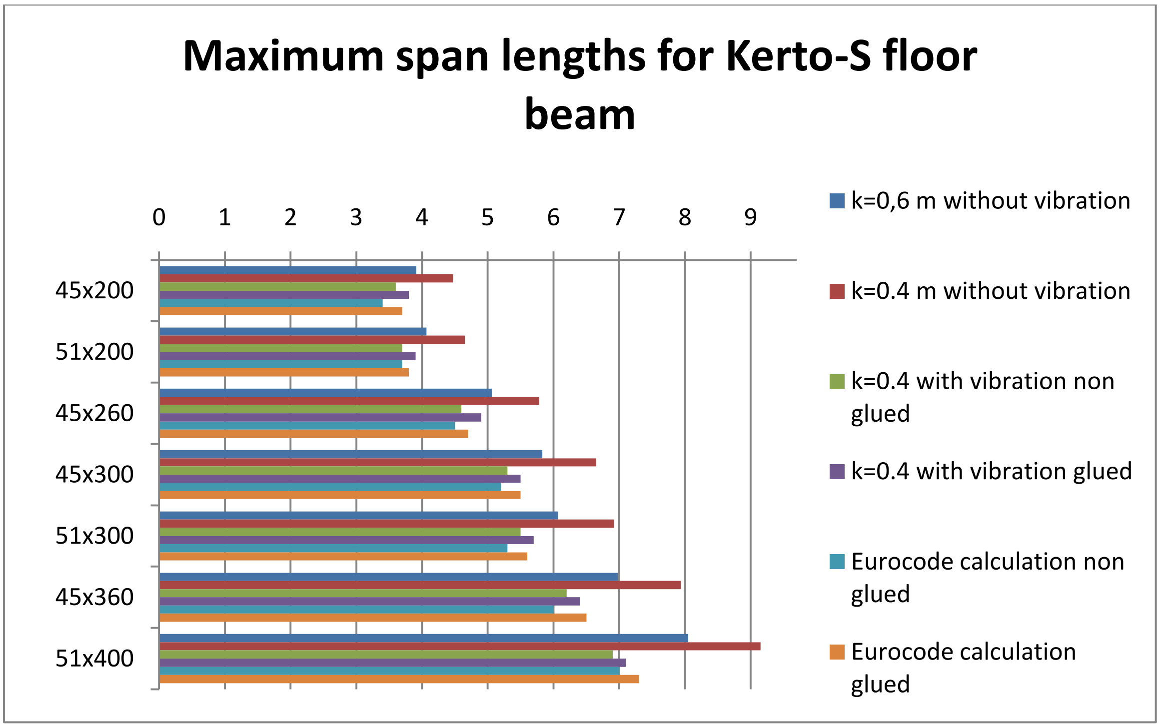
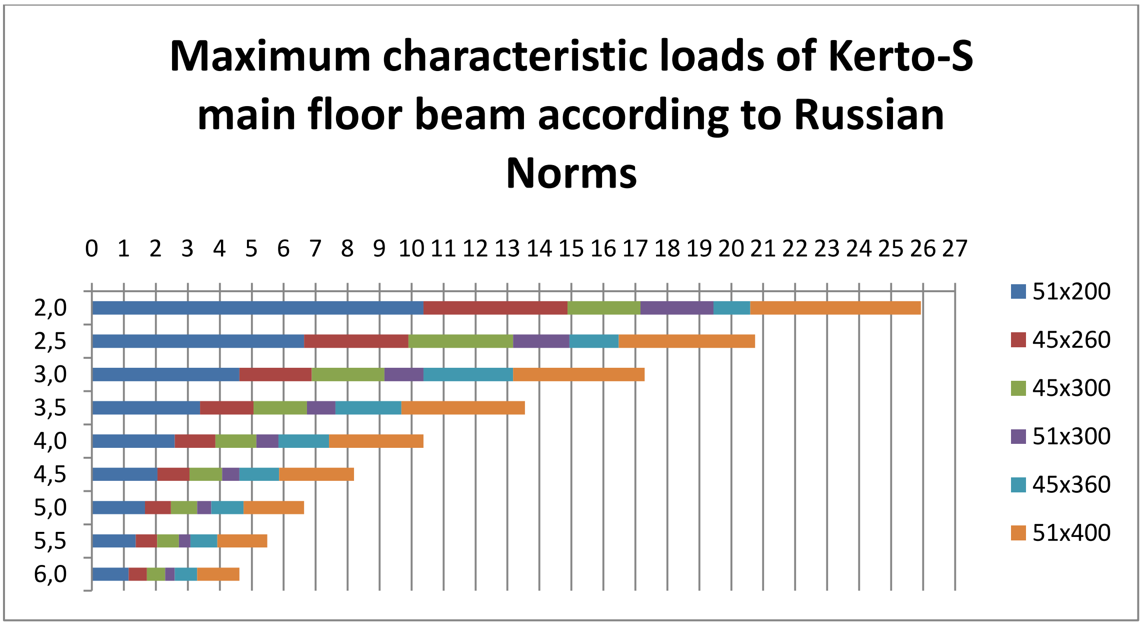
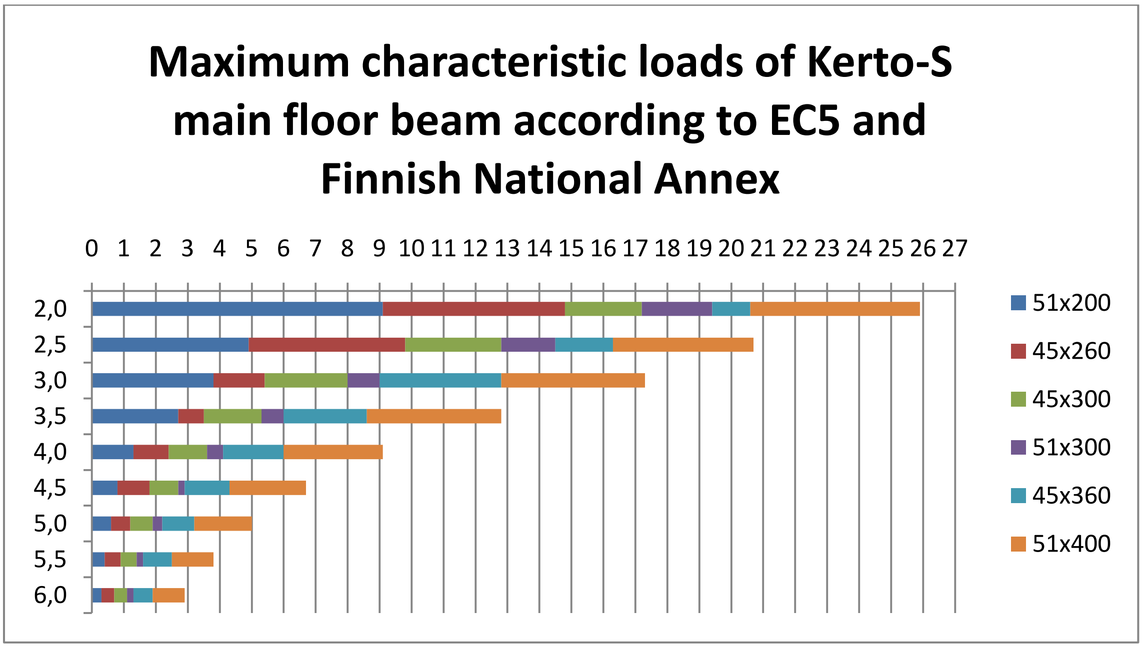
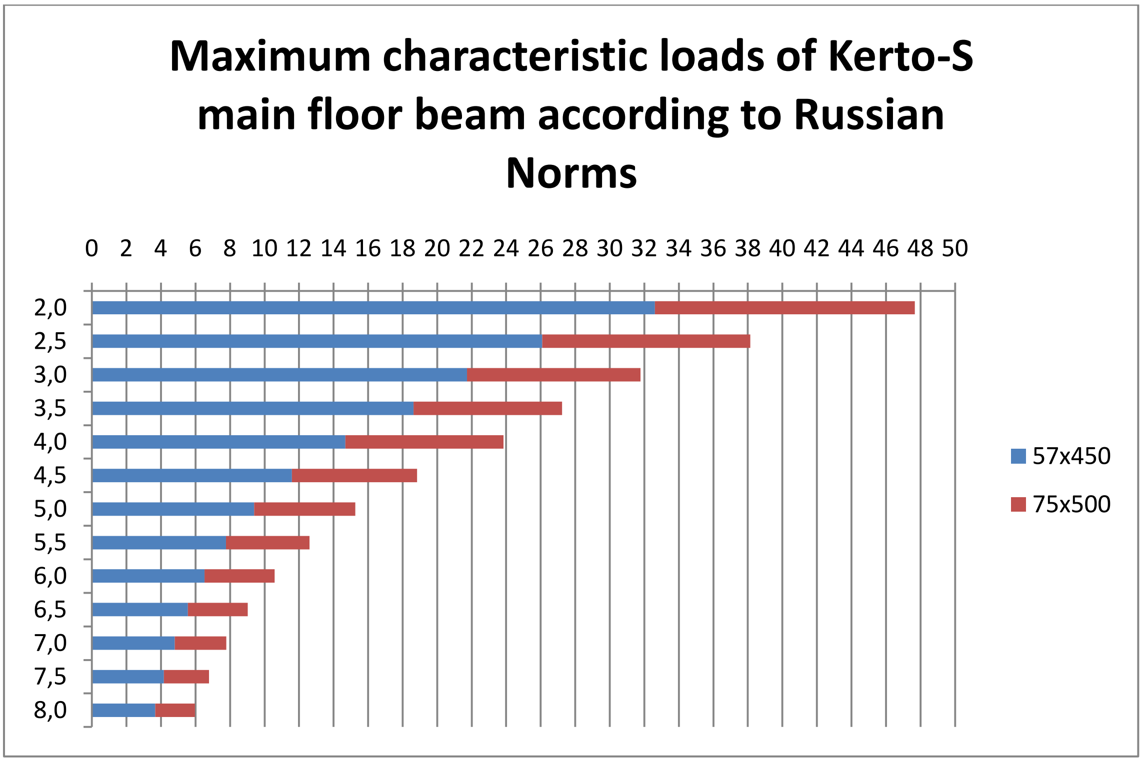
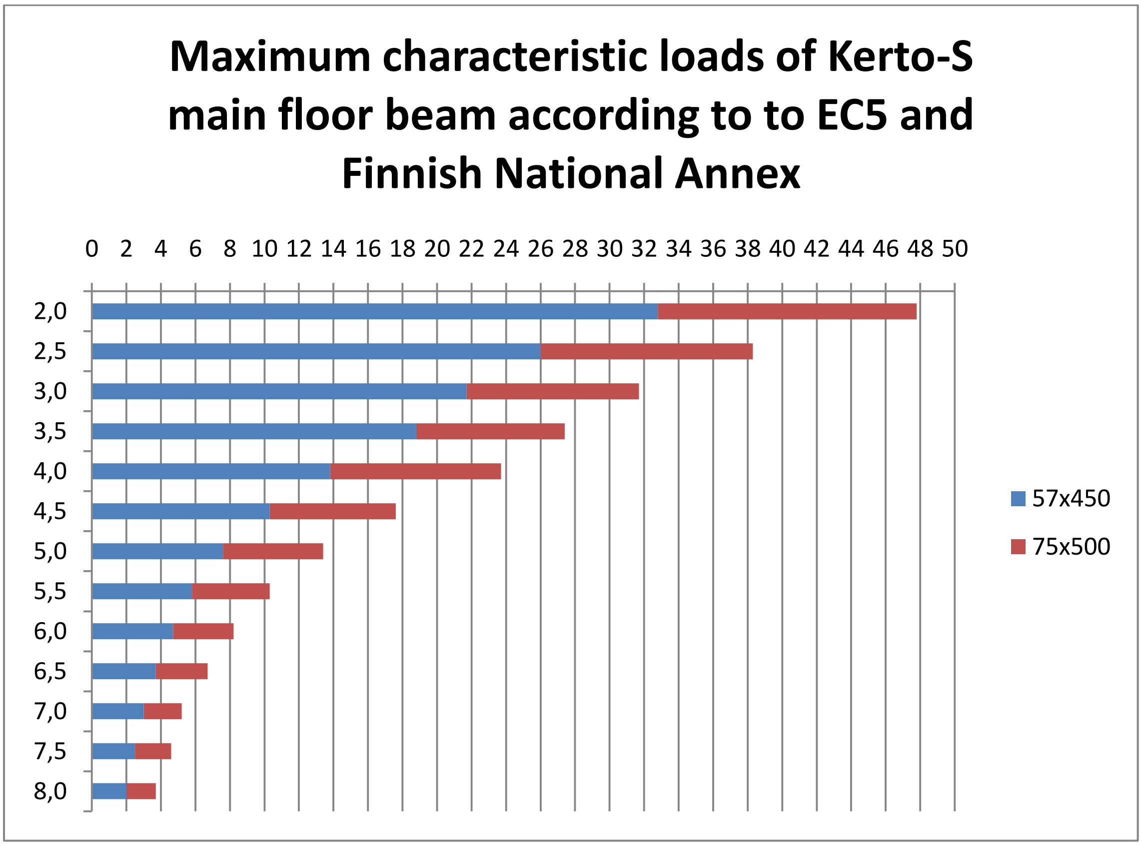


Diagram representing the maximum values of the characteristic loads for the main beam, calculated according to Russian norms, Eurocode 5 and Finnish National Annex .



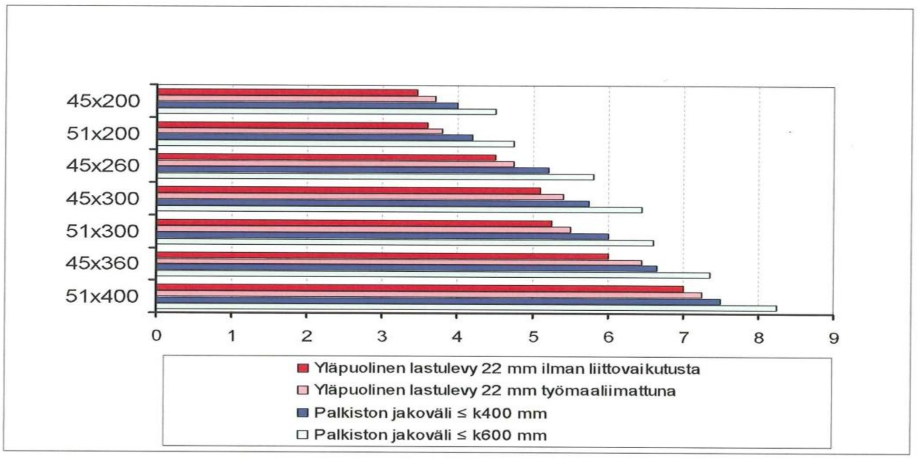



Maximum characteristic loads of Kerto-S main floor beam according to Russian Norms
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
2,0
2,5
3,0
3,5
4,0
4,5
5,0
5,5
6,0
6,5
7,0
7,5
8,0
57x450
75x500


Maximum characteristic loads of Kerto-S main floor beam according to to EC5 and Finnish National Annex
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
2,0
2,5
3,0
3,5
4,0
4,5
5,0
5,5
6,0
6,5
7,0
7,5
8,0
57x450
75x500

Diagrams showing maximum span lengths(of the Kerto-S floor beam) and characteristic loads(for the main beam),calculated according to Eurocode 5 and Finnish National Annex. Calculations have been made with Finnwood 2.2 RIL 205-1-2007.

KERTO-S –LATTIAPALKIN MAKSIMIJÄNNEVÄLI



Kuva 2. Kerto-S-lattiapalkin maksimijännevälit, tuen leveys ≥ 120 mm.

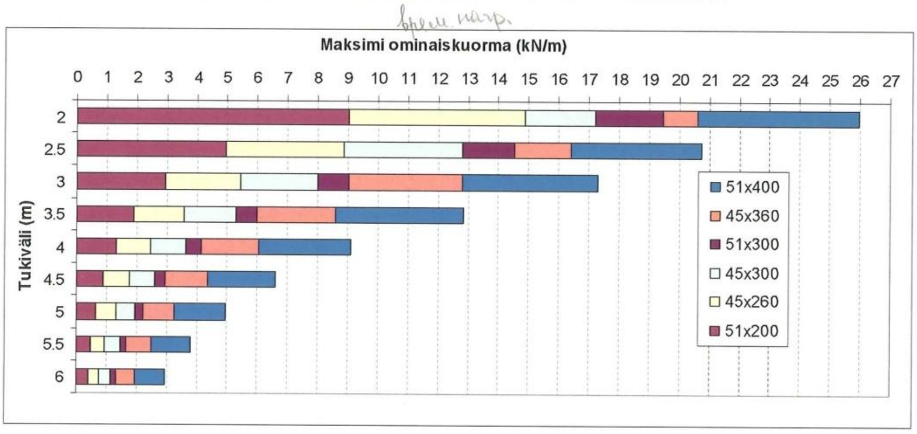
■ *Eurokoodin ja sen kansallisen sovellusohjeen RIL 205-1-2007:n mukainen mitoitus. Rakenteen omapaino 0,6 kN/m2, hyötykuorma 2,0 kN/m2, palkiston jakoväli k ≤ 400 mm. Värähtelymitoituksessa yläpuolinen lastulevy 22 mm ilman liittovaikutusta, yksi jäykistelinja palkiston keskellä ja neliön muotoinen huonetila, jossa lattian neljä reunaa tuettu. Lopputaipuma wfin ≤ L/300, alkutaipuma winst ≤ L/400.*

□ *Eurokoodin ja sen kansallisen sovellusohjeen RIL 205-1-2007:n mukainen mitoitus. Rakenteen omapaino 0,6 kN/m2, hyötykuorma 2,0 kN/m2, palkiston jakoväli k ≤ 400 mm. Värähtelymitoituksessa yläpuolinen lastulevy 22 mm työmaaliimattuna, yksi jäykistelinja palkiston keskellä ja neliön muotoinen huonetila, jossa lattian neljä reunaa tuettu. Lopputaipuma wfin ≤ L/300, alkutaipuma winst ≤ L/400.*

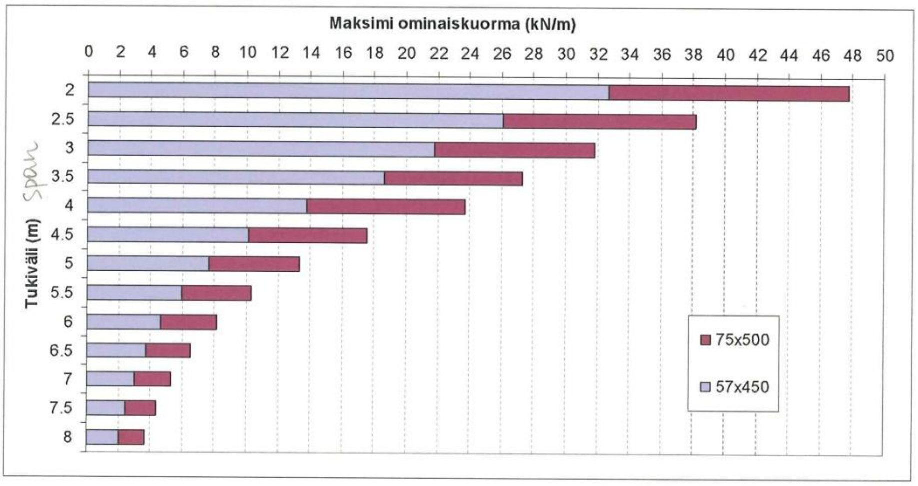
■ *Rak MK B10 mukainen mitoitus.* ***Palkiston jakoväli ≤ k 600 mm.*** *Rakenteen omapaino 0,6 kN/m^2. Hyötykuorma 1,5 kN/m^2. Taipuma w ≤ L/300 ja hyötykuorman aiheuttama taipuma w < 12 mm.*

□ *Rak MK B10 mukainen mitoitus.* ***Palkiston jakoväli ≤ k 400 mm.*** *Rakenteen omapaino 0,6 kN/m^2. Hyötykuorma 1,5 kN/m^2. Taipuma w ≤ L/300 ja hyötykuorman aiheuttama taipuma w < 12 mm.*

KERTO-S –PÄÄPALKIN MITOITUSTAULUKKO LATTIARAKENTEELLE



Kuva 3. Kerto-S pääpalkin mitoitustaulukko lattiarakenteelle käyttäen palkin standardipoikkileikkauksia. Mitoitus on tehty EC5 mukaan. Omapainon osuus 20%. Käyttöluokka 1-2. Tuen leveys 120 mm. Lopputaipuma $w_{fin} \leq L/300$, alkutaipuma $w_{inst} \leq L/400$.



Kuva 4. Kerto-S pääpalkin mitoitustaulukko lattiarakenteelle käyttäen esimerkkinä palkin standardipoikkileikkausta suurempia poikkileikkauksia. Mitoitus on tehty EC5 mukaan. Omapainon osuus 20%. Käyttöluokka 1-2. Tuen leveys 120 mm. Lopputaipuma $w_{fin} \leq L/300$, alkutaipuma $w_{inst} \leq L/400$.

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Certificate of conformance with attachments (Russian language).

СИСТЕМА СЕРТИФИКАЦИИ ГОСТ Р
ГОССТАНДАРТ РОССИИ

Добровольная сертификация

СЕРТИФИКАТ СООТВЕТСТВИЯ

№ РОСС FI.AE95.H00234

Срок действия с 05.03.2008 по 04.03.2011

0877696

ОРГАН ПО СЕРТИФИКАЦИИ рег. № РОСС RU.0001.11AE95
ПРОДУКЦИИ ОБЩЕСТВО С ОГРАНИЧЕННОЙ ОТВЕТСТВЕННОСТЬЮ "НИИ-ТЕСТ"
Юридический адрес: 127591, Москва, ул. Дубнинская, д.44а
Фактический адрес: 119121, Москва, Ружейный пер., д. 6, стр. 1, тел. (495) 241-51-36, факс (495) 241-51-36

ПРОДУКЦИЯ Конструкции деревянные клееные Kerto-S, Kerto-Q, Glulam GL24, GL28, GL32 согласно приложений на 2х листах.
Серийный выпуск.

код ОК 005 (ОКП):
53 6660

СООТВЕТСТВУЕТ ТРЕБОВАНИЯМ НОРМАТИВНЫХ ДОКУМЕНТОВ

Спецификации изготовителя.

код ТН ВЭД:
4418 90 100 0

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FMO Tapiola, Tuulikuja 2, FI-02100 Espoo (P.O. box 50 FI-02020 Metsa), Финляндия

НА ОСНОВАНИИ
Протокола испытаний № 820-261 от 29.02.2008 г. ИЛ Лесопромышленной продукции и тары ЗАО "Региональный орган по сертификации и тестированию" "РОСТЕСТ-МОСКВА", рег. № РОСС RU.0001.21ДМ30, адрес: 117418, Москва, Нахимовский пр., д. 31, санитарно-эпиддемиологического заключения № 78.01.06.536.П.004431.08.06 от 18.08.2006 до 18.08.2011 г. Территориальное управления федеральной службы по надзору в сфере защиты прав потребителей и благополучия человека по городу Санкт-Петербургу.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
Схема сертификации 3.

М.П.

Руководитель органа ______ подпись Т.В. Заболотная инициалы, фамилия

Эксперт ______ подпись Т.В.Раденкая инициалы, фамилия

Сертификат не применяется при обязательной сертификации

Бланк изготовлен ЗАО "ОПЦИОН" (лицензия № 05-05-09/003 МФ РФ уровень В) тел. (495) 648 6068, 208 7517, г. Москва, 2007 г.

Приложение к сертификату соответствия
№ РОСС FI.AE95.H00234 от 29.02.2008
(на двух листах)

характеристика	значение					
	Glulam GL 24h	Glulam GL 28c	Glulam GL 32c	Kerto-S Толщина 21 – 90 мм	Kerto-Q Толщина 21 – 24 мм	Kerto-Q Толщина 27 – 69 мм
Допуски для размеров при содержании влаги 10±2%						
Толщина	h≤400 +4 -2 h>400 +1.0 - 0.5%	h≤400 +4 -2 h>400 +1.0 - 0.5%	h≤400 +4 и -2 h>400 +1.0 - 0.5%	+ (0.8+0.03t) – (0.4+0.03t)	+0.8 – 0.4 – (0.4+0.03t)	+0.8 – 0.4 – (0.4+0.03t)
Ширина	±2	±2	±2	<400± 2.0 ≥400± 0.5 %	<400± 2.0 ≥400± 0.5 %	<400± 2.0 ≥400± 0.5 %
Длина	h≤2м ±2 2<h≤20м 0.1% h>20m ±20	h≤2м ±2 2<h≤20м 0.1% h>20m ±20	h≤2м ±2 2<h≤20м 0.1% h>20m ±20	± 5.0	± 5.0	± 5.0
Пятые процентильные значения						
Прочность на изгиб:						
В боковом направлении (глубина 300 мм)	24	28	32	44.0	28.0	32.0
Размерный эффект	-	-	-	0.12	0.12	0.12
Перпендикулярно слоям (толщ. от 21 до 90 мм)	-	-	-	50.0	32.0	36.0
Прочность на растяжение:						
Параллельно волокнам (длина 3000 мм)	16.5	16.5	19.5	35.0	19.0	26.0
Перпендикулярно волокнам, вбок	0.4	0.4	0.45	0.8	6.0	6.0
Перпендикулярно волокнам, перпендикулярно слоям	-	-	-	-	-	-
Прочность при сжатии:						
Параллельно волокнам	24.0	24.0	26.5	35.0	19.0	26.0
Перпендикулярно волокнам, вбок	2.7	2.7	3.0	6.0	9.0	9.0
Перпендикулярно волокнам, перпендикулярно слоям	-	-	-	1.8	1.8	1.8
Прочность при сдвиге:						
Параллельно волокнам	2.7	2.7	3.2	4.1	4.5	4.5
Перпендикулярно волокнам	-	-	-	2.3	1.3	1.3
Модуль упругости:						

Параллельно волокнам	9400	10200	11100	11600	8300	8800
Перпендикулярно волокнам, вбок	-	-	-	350	2000	2000
Перпендикулярно волокнам, перпендикулярно слоям	-	-	-	100	100	100
Перпендикулярно волокнам	-	-	-	-	-	-
Модуль сдвига:						
Параллельно волокнам	720	720	780	400	400	400
Перпендикулярно волокнам	-	-	-	400	-	-
Плотность	380	380	410	480	480	480
Средние значения						
Модуль упругости:						
Параллельно волокнам	11600	12600	13700	13800	10000	10500
Перпендикулярно волокнам, вбок	390	390	420	430	2400	2400
Перпендикулярно волокнам, перпендикулярно слоям	-	-	-	130	130	130
Модуль сдвига:						
Параллельно волокнам	-	-	-	600	600	600
Перпендикулярно волокнам	-	-	-	600	-	-
Плотность	-	-	-	510	510	510
Коэффициенты изменения размеров						
Толщина	-	-	-	0.0024	0.0024	0.0024
Ширина	-	-	-	0.0032	0.0003	0.0003
Длина	-	-	-	0.0001	0.0001	0.0001
Коэффициент сопротивления водяному пару						
В направлении толщины	-	-	-	80	62	62
В направлении ширины	-	-	-	82	9.5	9.5
В продольном направлении	-	-	-	3.9	4.7	4.7

Характеристики Kerto-S, Kerto-Q и Glulam

Руководитель органа по сертификации продукции — *Т.В. Заболотная*
Эксперт Системы сертификации ГОСТ Р — *Т.В.Радецкая*

Certificate of conformance (English language).

Certificate of conformance

№ POCC FI.AE95.H00234

Term of validity from 05.03.2008 till 04.03.2011

SERTIFYING AGENCY:

Co Ltd ”NII-Test” ,NII means research institution

Legal address

Real address

PRODUCT: Glued wooden structures Kerto-S, Kerto-Q, Glulam according to attachments on 2 sheets.

Serial production.

CORRESPONDS TO NORMATIVE DOCUMENTS REQUAREMENTS.

Producer specification.

PRODUCER:

“Metsaliitto Osuuskunta Finnforest”

CERTIFICATE ISSUED TO “Metsaliitto Osuuskunta Finnforest”

ACCORDING TO

Test report № 820-261 from 29.02.2008 from ”timber processing and packaging research laboratory” Close corporation “regional certifying and testing agency-ROSTEST MOSCOW” ,address

ADDITIONAL INFORMATION

Certification scheme №3

AGENCY DIRECTOR,EXPERT

Characteristic values of mechanical properties for Kerto.

KERTO AT A GLANCE

Characteristic values of mechanical properties

Values according to LVL standard (EN 14374 structural LVL) to be used in design according to Eurocode 5 (EN 1995)
N/mm^2 or kg/m^3

Property	Symbol	Kerto-S * Thickness 27 - 90 mm	Kerto-Q * Thickness 27 - 69 mm	Kerto-T **
Characteristic 5 % values				
Bending strength				
Edgewise	$f_{m,0,edge,k}$	44.0	32.0	27.0
Size effect parameter	s	0.12	0.12	0.15
Flatwise	$f_{m,0,flat,k}$	50.0	36.0	32.0
Tensile strength				
Parallel to grain	$f_{t,0,k}$	35.0	26.0	24.0
Perpendicular to grain, edgewise	$f_{t,90,edge,k}$	0.8	6.0	0.5
Compressive strength				
Parallel to grain	$f_{c,0,k}$	35.0	26.0	24.0
Perpendicular to grain, edgewise	$f_{c,90,edge,k}$	6.0	9.0	4.0
Perpendicular to grain, flatwise	$f_{c,90,flat,k}$	1.8	1.8	1.0
Shear strength				
Edgewise	$f_{v,0,edge,k}$	4.1	4.5	2.4
Flatwise	$f_{v,0,flat,k}$	2.3	1.3	1.3
Modulus of elasticity				
Parallel to grain	$E_{0,k}$	11600	8800	8800
Perpendicular to grain, edgeweise	$E_{90,edge,k}$	350	2000	-
Perpendicular to grain, flatwise	$E_{90,flat,k}$	100	100	-
Shear modulus	$G_{0,k}$	400	400	300
Density	ρ_k	480	480	410
Mean values				
Modulus of elasticity				
Parallel to grain	$E_{0,mean}$	13800	10500	10000
Perpendicular to grain, edgeweise	$E_{90,edge,mean}$	430	2400	-
Perpendicular to grain, flatwise	$E_{90,flat,mean}$	130	130	-
Shear modulus				
Edgewise	$G_{0,mean}$	600	600	400
Flatwise	$G_{0,mean}$	600	-	400

* VTT certificate No 184/03.　　** VTT statement RTE2719/05

The design of Kerto shall be made according to the national building codes and local Kerto type approvals. Alternatively, the national application document of EC5 and the values above can be used as a design basis.

Physical properties

	Kerto-S	Kerto-Q	Kerto-T
Moisture content (when leaving the mill)	10 %	10 %	10 %
Dimensional variation coefficient *			
Thickness	0.0024	0.0024	0.0024
Width	0.0032	0.0003	0.0032
Length	0.0001	0.0001	0.0001
Density (kg/m^3)	510	510	440
Fire resistance, charring rate (mm/min.)	0,70	0,70	**
Reaction to fire	D-s1, d0	D-s1, d0	**

* Dimensional variation of cross-section due to moisture content (change of moisture content in % x dimensional variation coefficient x cross-section in mm)

** Design shall be made according to the national type approval.

General tolerances for Kerto products

Thickness		+1 /-2 mm
Height	< 200 mm	+/- 1 mm
	200...600 mm	+/- 2 mm
	> 600 mm	+/- 0,5 %
Length		+/- 5 mm

Vibration calculation example.

Rakennuskohde	Työn nro.		Sivu
x	x		1 / 3
	Päiväys: x	Tekijä: x	
Suunnittelija	Sisältö		
x	Puuvälipohjan värähtelymitoitus (EC 5)		

VÄLIPOHJAN TIEDOT JA KUORMAT Info

Välipohjan tuentatapa		Neljä reunaa tuettu	
Pintalaatta		Ei pintalaattaa	
Välipohjan omapaino	g =	0,6	kN/m^2
Muuttuva kuorma	q =	2	kN/m^2
Muuttuvan kuorman pitkäaikainen osuus	Ψ_2 =	30%	
Huoneen suurin mitta		3,8	m
Välipohjan leveys		3,8	m

PALKISTO JA ALUSLATTIALEVYTYS Info

Palkin jänneväli	3800	mm
Palkkien k-jako	400	mm
Palkin tyyppi ja koko	Kerto-S 45x200	
Palkkien tuplaus	Ei tuplapalkkeja	
Levyn tyyppi	Lastul. 22 (EN312-6)	

ALUSLATTIALEVYN KIINNITYS

Liitintyyppi	Ruuvi 4,0x50	
Liitinjako	200	mm

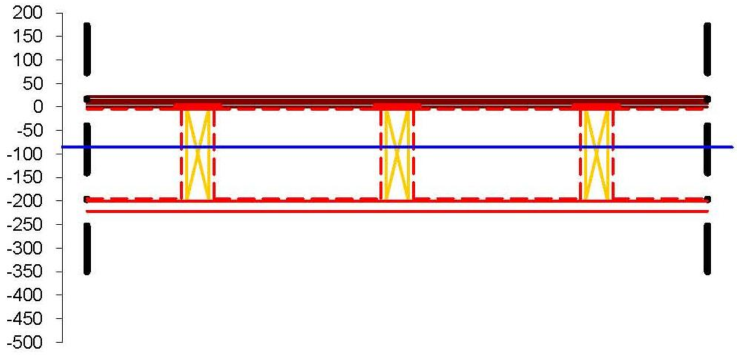
LIITTORAKENNEVAIKUTUKSEN HUOMIOIMINEN Info

Liittorakenteen liitostapa	Liimaliitos
Liimaustyön suoritus	Työmaaliimaus

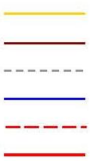
POIKITTAISJÄYKISTEET Info

Poikittaisjäykisteiden määrä (ks. Info)	1 jäykistelinja

Rakennuskohde	Työn nro.		Sivu
x	x		2 / 3
	Päiväys: x	Tekijä: x	
Suunnittelija	Sisältö		
x	Puuvälipohjan värähtelymitoitus (EC 5)		



OMINAISTAAJUUS	**11,7 Hz**
TAIPUMA PISTEKUORMASTA	**0,64 mm**
TAIPUMAN KÄYTTÖASTE	**96%**



MATERIAALIT JA POIKKILEIKKAUS

$E_{0,mean}$	13800	N/mm^2	*Palkin kimmomoduuli*
$E_{c,mean}$	2100	N/mm^2	*Levyn puristuskimmomoduuli (aina heikomman suunnan arvo)*
E_{mean}	3500	N/mm^2	*Levyn taivutuskimmomoduuli palkiston suunnassa*
E_{mean}	3500	N/mm^2	*Levyn taivutuskimmomoduuli palkistoa vastaan kohtisuor. suunnassa*
A_{palkki}	9000	mm^2	*Palkin poikkileikkauksen pinta-ala*
b_{ef}	400	mm	*Levyn tehollinen leveys liittorakenteessa*
A_{levy}	8800	mm^2	*Levyn poikkileikkauksen tehollinen pinta-ala liittorakenteessa*

NEUTRAALIAKSELI

K_{ser}	1681,87	N/mm	*Liittimen siirtymäkerroin*
γ_{levy}	1,00		*Apusuure levylle (liittorakenne)*
γ_{palkki}	1,00		*Apusuure palkille (liittorakenne)*
a_1	96,62	mm	*Etäisyys neutraaliakselista levyn painopisteeseen*
a_2	14,38	mm	*Etäisyys neutraaliakselista palkin painopisteeseen*

VÄLIPOHJAN JÄYKKYYS PALKISTON SUUNNASSA

$(EI)_{palkisto}$	1284304413	Nmm^2/mm	*Palkiston taivutusjäykkyys*
$(EI)_{betoni}$	0	Nmm^2/mm	*Betonilaatan taivutusjäykkyys*
$\Sigma(EI)_L$	1284304413	Nmm^2/mm	*Taivutusjäykkyys yhteensä (palkisto, betonilaatta)*

Rakennuskohde	Työn nro.		Sivu
x	x		3 / 3
	Päiväys x	Tekijä x	
Suunnittelija	Sisältö		
x	Puuvälipohjan värähtelymitoitus (EC 5)		

VÄLIPOHJAN JÄYKKYYS PALKISTOA VASTAAN KOHTISUORASSA SUUNNASSA

$(EI)_{levy}$	3105666,67	Nmm^2/mm	*Aluslattialevyn taivutusjäykkyys*
$(EI)_{betoni}$	0	Nmm^2/mm	*Betonilaatan taivutusjäykkyys*
$(EI)_{jäykiste}$	35429253,9	Nmm^2/mm	*Poikittaisjäykisteiden taivutusjäykkyys*
$\Sigma(EI)_B$	38534920,6	Nmm^2/mm	*Taivutusjäykkyys yhteensä (levy, betonilaatta, poikittaisjäykisteet)*

VÄLIPOHJAN TAIPUMA PISTEKUORMASTA

k_L	1,37		*Taipumarajan korotuskerroin*
$\delta_{sallittu}$	0,69	mm	*Välipohjan sallittu taipuma 1 kN:n pistekuormasta*
k_δ	0,44		*Apusuure jäykkyyksien suhteen*
δ_{laatta}	0,68	mm	*Välipohjan taipuma 1 kN:n pistekuormasta*
δ_{palkki}	2,35	mm	*Yksittäisen palkin taipuma 1 kN:n pistekuormasta*

VÄLIPOHJAN OMINAISTAAJUUS

m_1	61,16	kg/m^2	*Välipohjan omapaino*
m_2	61,16	kg/m^2	*Muuttuvan kuorman pitkäaikainen osuus*
$\Sigma(EI)_L$	1035000	Nm^2/m	*Taivutusjäykkyys palkiston suunnassa*
$\Sigma(EI)_B$	38534,9206	Nm^2/m	*Taivutusjäykkyys palkistoa vastaan kohtisuorassa suunnassa*
f_1	11,75	Hz	*Välipohjan ominaistaajuus*

MITOITUSTULOKSET

Välipohjan taipuma	0,68 mm	**OK!**
Välipohjan ominaistaajuus	11,75 Hz	**OK! Korkeataajuuslattia**

MUUTA

Aluslattialevyn tyyppi:	Ympäripontattu lastulevy
Aluslattialevyn kiinnitys:	Ruuvi 4,0x50
Aluslattialevyn liittimien k-jako:	200 mm
Liittorakenne:	Ei liittorakennetta
Liittorakenteen liitostapa:	-

- Lastulevy asennetaan siten, että levyn pitkä sivu tulee kohtisuoraan palkkeja vastaan
- Aluslattialevyn ponttisaumoissa sekä levyn ja palkin välissä suositellaan käytettäväksi polyuretaaniliimaa, vaikka liimausta ei hyödynnettäisikään värähtelymitoituksessa (narinan esto)

-

HUOMIO!

Välipohja tulee mitoittaa lisäksi staattisille kuormille murto- ja käyttörajatilassa.

Mathcad calculation example

Secondary Kerto-S floor beam calculation

The present calculations are set for secondary intermediate floor beams and made according to rules and recommendations of the following Russian normative documents:

- STO 36554501-002-2006 "Wooden laminated and solid timber structures" - [1]
- STO 36554501-015-2008 "Loads and Influences" - [2]

Service class C2 (A3 according to Russian standard) was used.

1. Kerto- S cross section dimensions (характеристики сечения)

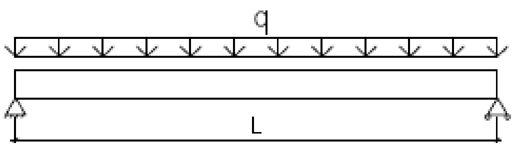
$b := 45mm$ -width (*ширина*)

$h := 260mm$ -height (*высота*)

$k := 600mm$ -spacing (*шаг*)

$A := b \cdot h$ -cross section area (*площадь*)

$A = 0.012 \cdot m^2$



3. Strength properties (значения прочностных характеристик)

$R_u := 20 \frac{N}{mm^2}$ -design bending strength along the grain (*прочность на изгиб вдоль волокон*)

$R_c := 2 \frac{N}{mm^2}$ -design compressive strength perpendicular the grain, edgewise (*прочность на сжатие вдоль волокон по кромке*)

$R_{ск} := 2.5 \frac{N}{mm^2}$ -design shear strength along the grain, edgewise (*прочность на скалывание вдоль волокон по кромке*)

$E := 10000 \frac{N}{mm^2}$ -modulus of elasticity (*модуль упругости*)

4. Service factor values (значения коэффициентов условий работы)

$\gamma_n := 1$ -factor depends on reliability class of the building (see table 9a in [1]) (*коэффициент, зависящий от класса ответственности здания*)

$m_v := 1$ -factor depends on operating conditions of the structure (see table 5 in [1]) (*коэффициент, зависящий от условий эксплуатации конструкции*)

5. Loads collection (сбор нагрузок)

$G_1 := 0.6\frac{kN}{m^2}$ -Kerto-S beam self weight (*собственный вес балки Керто-С*)

$\gamma_{f1} := 1.1$ -safety factor for timber structures (see table 2.1 in [2]) (*коэффициент надежности по нагрузке для веса деревянных конструкций*)

$P_1 := 1.5\frac{kN}{m^2}$ -uniformly distributed imposed load (see table 3.3 in [2]) (*равномерная распределенная временная нагрузка*)

$\gamma_{f3} := 1.3$ -safety factor for uniformly distributed load (see para. 3.2.2) (*коэффициент надежности по нагрузке для равномерно распределенной нагрузки*)

$q_{k.1} := \left(G_1 + P_1\right)$ -characteristic values of full load (*нормативное значения полной нагрузки*)

$q_{k.1} = 2.1\cdot\frac{kN}{m^2}$

$q_{k.2} := q_{k.1}\cdot k = 1.26\cdot\frac{kN}{m}$

$q_{d.1} := G_1\cdot\gamma_{f1} + P_1\cdot\gamma_{f3}$ -design values of full load (*расчетное значения полной нагрузки*)

$q_{d.1} = 2.61\cdot\frac{kN}{m^2}$

$q_{d.2} := q_{d.1}\cdot k = 1.566\cdot\frac{kN}{m}$

6. Ultimate limit state design
(расчет по первой группе предельных состояний)

- ***bending (расчет на прочность по нормальным напряжениям)***

$\frac{M}{W} \le R_u$ -see formula 17 in [1]

$W := \frac{b \cdot h^2}{6}$ -section modulus (*расчетный момент сопротивления поперечного сечения*)

$W = 5.07 \times 10^5 \cdot mm^3$

$\sigma_{limit} := R_u \cdot \frac{m_v}{\gamma_n} = 20 \cdot \frac{N}{mm^2}$

$l_1 := \sqrt{\frac{8 \cdot W \cdot \sigma_{limit}}{q_{d.2}}} = 7.197\,m$

- ***shear (расчет на прочность по касательным напряжениям)***

$\frac{Q \cdot S}{I \cdot b} \le R_{ск}$ -see formula 18 in [1]

$\tau_{limit} := R_{ск} \cdot \frac{m_v}{\gamma_n} = 2.5 \cdot \frac{N}{mm^2}$

$l_2 := \frac{4 \cdot A \cdot \tau_{limit}}{3 \cdot q_{d.2}} = 24.904\,m$

7. Serviceability limit state design
(расчет по второй группе предельных состояний)

- ***deflection (определение прогиба)***

$f \le f_u$ -see formula 10.1 in [2]

$I := \frac{b \cdot h^3}{12}$ -second moment of area (*момент инерции сечения*)

$I = 6.591 \times 10^{-5} \cdot m^4$

$k_s := 19.2$ -factor, which includes shear deformation (see table Г.3 Appendix Г in [1]) (*коэффициент, учитывающий влияние деформаций сдвига от поперечной силы*)

$K := 1$ -factor, including varability of section height, equa to 1 for full cross section (see table Г.3 Appendix Г in [1]) (*коэффициент, учитывающий переменность высоты сечения,равен единице для постоянного сечения*)

Given

$$\frac{l_4}{250} = \frac{5 \cdot 1.485 \cdot l_4^{\,4}}{384 \cdot 10^7 \cdot 6.591 \cdot 10^{-5} \cdot 1} \cdot \left[1 + 19.2 \cdot \left(\frac{0.26}{l_4}\right)^2\right]$$ -beam deflection (*прогиб балки*)

$$Find(l_4) \rightarrow (5.0628848757919165782 \quad -2.5314424378959582891 + 4.5301790747322448333i \quad -2.5314424378959582891 -$$

8. Joint design (расчет соединений)

- ***bearing (расчет на смятие)***

$s := 120mm$ -width of the support (*ширина опоры*)

$A_{bearing} := s \cdot b$ -bearing area (*расчетная площадь смятия*)

$$T := R_c \cdot \frac{m_v}{\gamma_n} \cdot A_{bearing} = 10.8 \cdot kN$$

$$l_5 := 2\frac{T}{q_{d.2}} = 13.793\,m$$