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DESIGN PRINCIPLES FOR LOG BUILDINGS

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This guideline presents design principles for prefabricated detached log houses and other log buildings intended for continuous round-the-year use, as well as the components employed therein. The principles are also to be observed in connection with log buildings intended for part-time use, where applicable.

CONTENTS

1. TERMINOLOGY

The following terms are applicable to log construction presented in this guideline.

A **log** is a solid building material with a thickness of at least 70 mm, produced by industrial planing or lathing and intended for use primarily in wall structures. Logs may have seal recesses and crack-guiding grooves.

A **rectangular log** (HH) is shown in Figure 1. Logs may be tongued and grooved.

A **round log** (Ø) is shown in Figure 2. It is round or nearly round in cross-section.

A **laminated (glued) log** is shown in Figure 3. It is glued together from two or more pieces, with either a vertical or horizontal seam.

Figure 1. Profile of a rectangular log

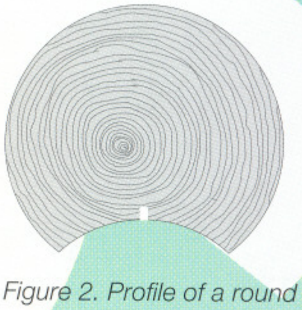


Figure 2. Profile of a round log

Figure 3. Profile of a glued log (vertical and horizontal)

A BRIEF HISTORY OF LOG BUILDINGS

Construction of log buildings has, for natural reasons, evolved in the coniferous forest zone. The earliest log buildings with notched, intersecting corners date from the Iron and Bronze Ages (although in Switzerland, there are horizontal log structures that go back to the Stone Age). In Finland, the oldest log building still in existence is a chapel dedicated to St. Henry, situated in Kokemäki, South-Western Finland. It was built around the year 1400.

After World War I, board-clad timber-framed houses rapidly gained popularity in Finland. In the countryside, however, log maintained its position as the primary building material up until the 1940s, but then its use in round-the-year houses declined little by little until it almost came to a complete stop. On the other hand, log has always been the dominating material for summer cabins. Today, about 70 percent of new leisure homes in Finland are built of log.

In the early 1950s, industrial log production expanded in Finland. Initially, the development work focused almost solely on the production process. Gradually, more attention was devoted to the product itself. The 1970s and 1980s were an era of vigorous development for log houses as an industrial product. The industry looked intensely for solutions to deal with sealing, insulation and compression problems, and the development of prefabricated log buildings continues today. Since the 1990s, log has again become an attractive option for Finns building homes for themselves.

Approximately 70 percent of all log houses built in Finland today are prefabricated, i.e. industrially manufactured. Modern computer-aided industrial prefabrication allows, for instance, pre-drying of logs, resulting in the highest possible dimensional accuracy. As the log frame can be erected on site in just a few days, the house is quickly constructed and protected against the weather.

Prefabricated log buildings made in Finland even attract attention abroad: In 2000, log buildings were exported to over 30 countries. Finland is the leading manufacturer of prefabricated log buildings, and in fact, the largest individual company manufacturing log buildings is based in Finland.

Notch jointing refers to a technique of notching logs to make a strong interlocking joint at corners.
A **log intersection** refers to the point at which two logs cross at right angles (see Figure 4).
A **long corner** is a wall or corner joint at which the ends of intersecting logs extend beyond the point of intersection.
A **seal recess** refers to the seam profile between the logs assembled on top of each other.
A **seal** refers to the packing material inserted between the logs. This is primarily to prevent unwanted air infiltration.
Dowelling refers to the method of preventing the individual logs in a wall from moving laterally. This is implemented by joining two or more logs in a perpendicular position, generally by means of wooden or steel dowels.
Cracking: It is characteristic to wood that the tangential drying shrinkage (i.e. shrinkage along the circumference of a log) is approximately twice the radial drying shrinkage. For this reason, and because the drying begins from the surface of the wood, radial cracks develop in the log. Cracks can be guided by cutting grooves into the log.
Settling refers to the sinking of a wall due to drying shrinkage, load stresses and compression of seams.
Through-bolting refers to the use of a threaded bolt which extends over the entire height of the wall (see Figure 5) and which can be tightened.
A **log beam** is a load-bearing beam made of one or more logs (see Figure 6).
A **tongued jamb** (or loose tongue) is a wooden post with (or without) a tongue that fits into a vertical groove cut into the log ends of a wall opening. It prevents lateral movement and allows for settling of the wall, and thus facilitates the attachment of non-settling structures, such as doors and windows. See Figures 7 and 8.
Screw-leg: Some components of a log building do not settle to the same extent as the log walls. When structures are supported on these components, the settling allowance is facilitated by means of screw-legs, which can be adjusted as settling progresses (see Figure 9).
A **settling spacer** is a wooden wedge placed at the ends of wooden posts. It can be removed as the building settles.
The **wall-support posts** are perpendicular wooden posts, which prevent buckling of long runs of wall between load-bearing points. The posts are connected to each other through the wall by bolts. It is also possible to bolt a post on one side of the wall to support it.
A **tenon** refers to a wooden or steel dowel, which is used to dowel a log wall, or a toothed plate connector made of steel, which is used to build up a log beam.

Areas of a building

Net floor area ('htm2') and gross floor area ('kem2'), calculated in accordance with the Finnish standard SFS 5139 (RT 12-10277, 1985), shall be given for each building. The areas of those parts of the building, which are not included in either of the said areas, can be given separately. These parts of the building include galleries (gallery area), terraces (terrace area), balconies (balcony area) and cellars (cellar area).

Figure 4.
A log intersection

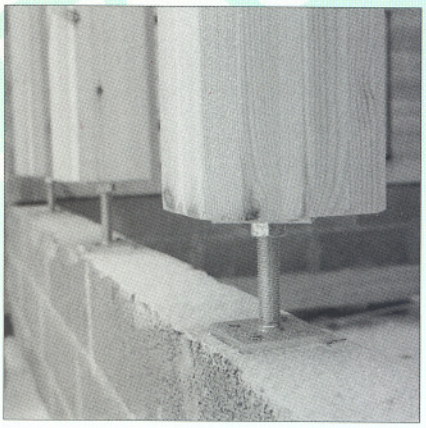
Figure 5.
Through-bolting

Figure 6.
A log beam

Figure 7.
A tongued jamb in a door opening

Figure 8. A window
fastened to tongued jambs

Figure 9.
A screw-leg



2. MOISTURE CHARACTERISTICS OF WOOD

Wood is a hygroscopic material, meaning that its moisture content depends on the humidity (and temperature) of the air. Wood does not, however, respond quickly to changes in the relative humidity of the air. For this reason, there is little diurnal (day/night) variation in the moisture content of a log wall in the circumstances prevailing in Finland. Research has shown that moisture variation in a log takes place within a surface layer of approximately 5 cm deep on both sides of the log wall. Thus, the internal moisture of a thick wall is practically unchanged year after year once equilibrium moisture content is achieved. The final moisture content of a log in a heated interior space is approximately 8 % of dry weight, and in exterior walls approximately 14 % of dry weight. In exterior walls, however, significant variation in the moisture content may occur because of exposure to direct sunlight, type of structural protection etc.

Shrinkage of wood varies in relation to the grain of the wood. Shrinkage along the longitudinal axis (parallel to the grain) is minor in comparison to shrinkage in other directions. As the wood loses its initial moisture (which is about 29 %) and dries fully, tangential shrinkage (around the circumference of the log) amounts to about 8 %, while radial shrinkage is about 4 % (see Figure 10).

Since the tangential shrinkage is twice the radial shrinkage, stresses develop in the drying wood. When these stresses exceed the wood's tensile strength, cracks develop. The moisture content and the size of the log govern the size of the cracks. In logs with large diameters, the cracks, which result from natural drying, may be extensive. According to research, the cracks do not have any detrimental effect on thermal transmittance or stress values. Thermal transmittance is even slightly lower at a crack, owing to the stationary air within the crack.

As the relative humidity of the air changes, the width of the cracks also varies in relation to the log's moisture content. In a heated building, the cracks on the interior side of the log are largest during the winter, when the log's moisture content is low. In the summer the cracks are about one third smaller than in the winter. The moisture in the pith of the log at the time of construction dissipates slowly – generally only after heating of the building begins. This drying process unavoidably results in large cracks, which close up somewhat, once the pith has dried out.

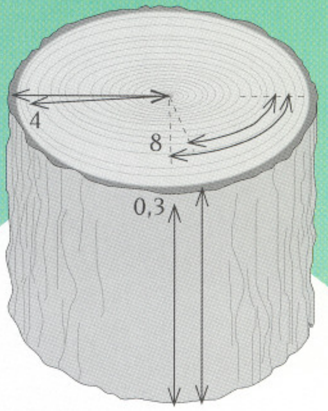


Figure 10. Drying shrinkage (%) of wood in different directions

3. SPECIAL CHARACTERISTICS OF LOG BUILDINGS

3.1 Settling

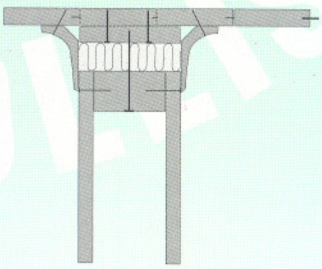
Settling is caused by the natural drying of wood, the compression of seams in log walls and the load stresses, and it must be taken into consideration in the design of structures. In log structures, the settling ranges from 10 to 50 mm per vertical metre, depending on the type of log. Most of this settling is due to the wood drying. In view of their lower moisture content, interior partition walls settle about 10 mm more per vertical metre than exterior walls do.

When brick walls, light-weight framed partitions, staircases, fittings and posts are joined to log structures, consideration must be given to the settling of the latter. A settling allowance must be provided for non-settling structures. If the non-settling structure is load-bearing, it must be fitted with a screw-leg. Wooden posts are fitted with settling spacers or screw-legs (see Figure 9) according to the estimated degree of settling.

Consideration should also be given to the following factors during design:

- in structures supported by foundations at different levels, a greater degree of settling of legs resting on the lower foundation,
- in extending or expanding old log buildings, the fact that settling in the new and old parts of the building takes place over different periods,
- in leading ductwork through floors, ceilings and roofs, the need to ensure that fire protection clearances between the ductwork and wooden structures are maintained after settling and to allow the structures to settle without obstruction.

Light-weight framed partitions are attached to log walls by means of, for instance, battens which have elliptical slots to allow the screws to move downwards as the log structure settles (see Figure 11). Also, a



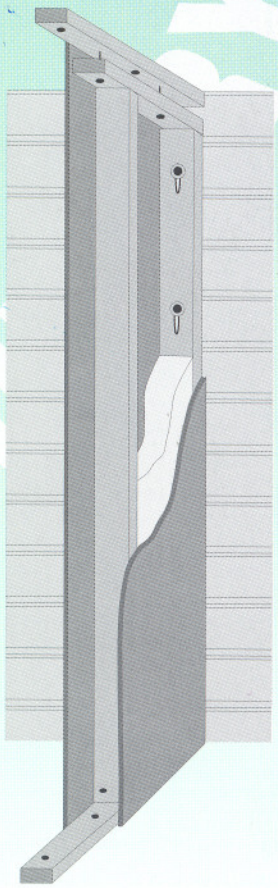


Figure 11. Connection of a light-weight framed partition to a log wall

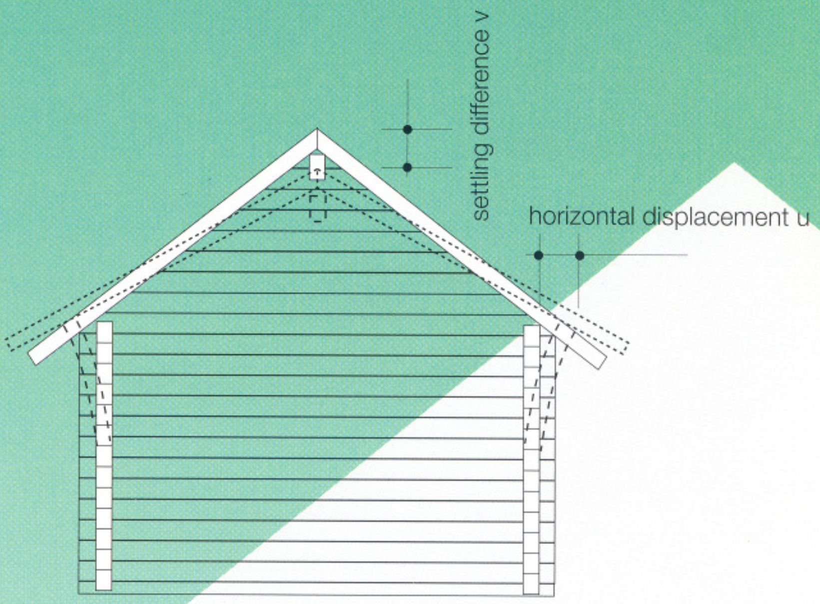


Figure 13. Movement of roof structures. The horizontal displacement $u = v \times \tan \alpha$, where v is the settling of the gable and α is the pitch of the roof.

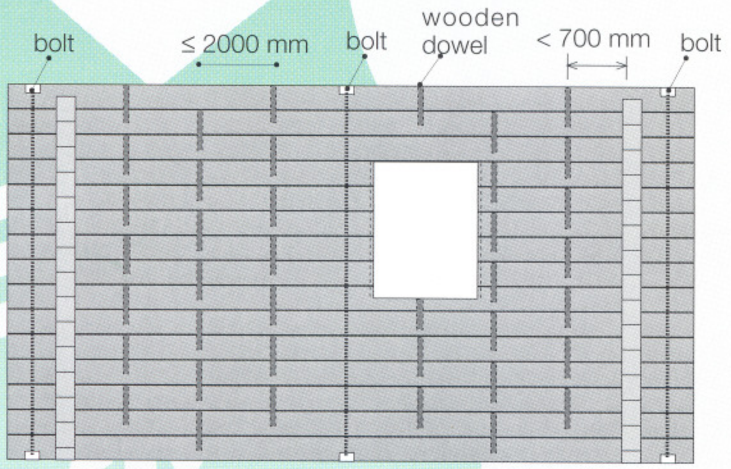


Figure 14. Dowelling of a log wall

framework for additional insulation is fastened to a log wall so as to allow for settling.

Window and door openings are strengthened at the sides with wooden tongued jambs (or loose tongues), which are fitted into the grooves cut in the log ends. They allow the surrounding log wall to settle and prevent lateral movement of the logs (see Figures 7 and 8).

In steep roofs with a log gable (i.e. the upper and lower ends of the rafters rest on the log wall), the difference in settling resulting from the height differential between the apex of the gable and the top of the gable causes the lower ends of the rafters to be displaced horizontally (see Figure 13). As a consequence of this, the walls parallel to the ridge of the roof will tend to bulge outwards, unless the rafter fastenings have a mechanism to allow for this displacement.

Traditionally, wooden dowelling and log intersections have been used to make log walls into rigid, integral structures. Wooden or steel dowels prevent the logs from warping out of place, especially in long walls and around openings. The distance between two dowels must not exceed 2000 mm (see Figure 14).

3.2 Tightness

In the winter, the moisture contained in a log moves into the interior air and thus slows the rate at which the humidity in the interior space declines. The packing material used in the seal recesses and notched joints will prevent unwanted infiltration of air. The drying cracks in the logs do not extend through the entire log, and consequently, do not affect the tightness of the log wall.

3.3 Durability and protection of log wall

The moisture content of wood is the most important factor affecting the durability of a log. A moisture content of at least 20 % and a temperature of at least 5 °C are necessary for mould and rot fungi to develop. The moisture content of the wood exceeds the said value only when the relative humidity of the air has remained above 85 % for a long period of time.

Methods of protecting the exterior log wall

The purpose of protecting the exterior wall of a log building is to maintain the esthetic and structural characteristics of wood. These characteristics are deteriorated by the growth of fungi (rot and mould), by dampness and by ultraviolet radiation (sunlight). The methods of protecting the log wall can be classified into three categories: structural protection, chemical protection and coating. The best result is usually achieved by combining these three methods.

Structural protection

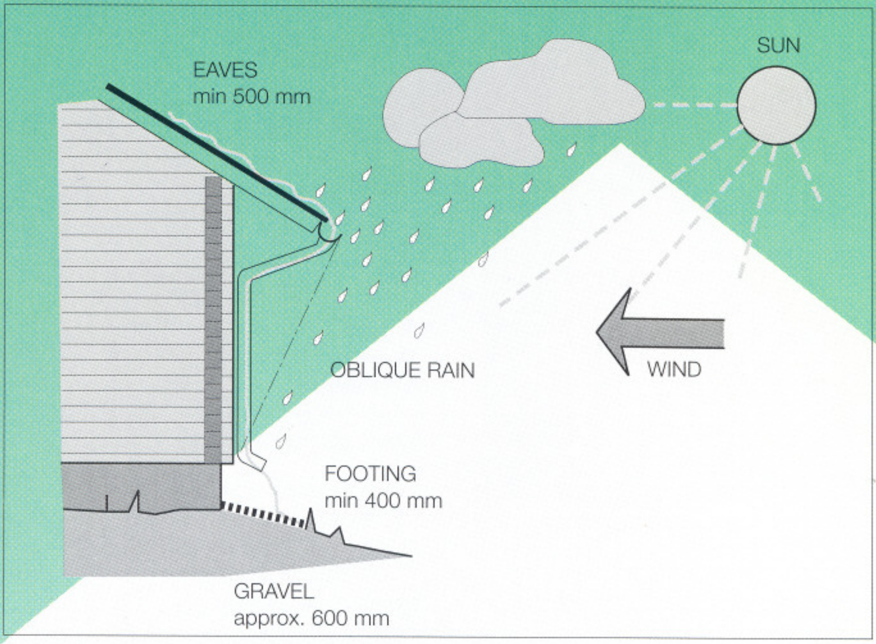
Structural protection aims at minimizing the moisture load on the surface of log.

The exterior wall should be protected against capillary water rising from the soil as well as against oblique rain and splash water.

In the design of structures, consideration should be given to a free flow of air, which will dry the exterior wall efficiently.

Sufficiently long eaves give effective protection against oblique rain and reduce the effect of sunlight. The eaves should be at least 500 mm long. Preferably, all terraces and balconies made of log or wooden structures should be covered.

The log seams should be designed so that water running down the wall does not stay in the seam ("drip beak structure"). The packing should not extrude out of the seam, because wet packing creates favourable conditions for fungi.



Gutters and downpipes guide the rainwater to the soil, preventing the wind from blowing water onto the wall. The downpipe shoe must be built so that splashing water does not hit the wall. The bottoms of window openings must be fitted with weather strips, which are tilted outwards.

The footing must be sufficiently high, at least 400 mm above the soil, to prevent melted snow, water and vegetation from rotting the lowermost logs.

It is absolutely necessary to cut the rise of capillary water by installing a damp course, for instance, bitumen felt or a coating of bitumen between the footing and the lowest logs.

Chemical protection and coating

Logs are treated with surface treatment agents for the following purposes:

- to protect the wood chemically against fungi (= not suitable for living),
- to fill the cells of the surface wood, thus preventing the humidity from being absorbed into the wood,
- to protect the surface of the wood against ultraviolet radiation, and
- to form a water repulsive film on the surface of the wood.

Treatment agents are usually divided into paints and wood preservatives. Paints fill the wood more, and they form a thicker film with a poorer water vapour impermeability. Wood preservatives soak deeper into the wood and they do not necessarily form any film at all on the surface of the wood.

Wood preservatives generally used on log walls contain small amounts of fungicides in addition to a thinner.

The surface treatment liquids are either colourless, transparent or opaque. Opaque compounds are more effective than colourless or transparent compounds in protecting against ultraviolet radiation.

The compounds penetrate into the wood to a depth of a few millimetres. The wood preservatives may or may not form a film on the surface of the wood. It is important that the film forming on the log is highly water vapour impermeable: Being a hygroscopic material, solid log tends to balance the moisture content in accordance with the relative humidity of the air (this is why some paints are not suitable for log walls). If the film does not allow the water vapour to penetrate through it, the pressure of the water vapour will detach the film from the surface of the wood.

Priming should be done as soon as possible after the building is constructed because ultraviolet radiation immediately penetrates into the wood to a depth of about 0.1 millimetre and starts dissociating lignin, an agglutination agent in the wood cells. The more the ultraviolet radiation dissociates lignin, the more poorly the surface treatment agent adheres to the wood.

Priming also prevents the development of mould and blue rot fungi.

The effect of ultraviolet radiation on South-facing walls is up to five times as great as North-facing walls. For this reason, the walls facing South and West usually need re-treating before other walls.

3.4 Lengthening of logs

Both rectangular and round logs are lengthened by finger or circular joints or by using connectors which prevent lateral and longitudinal movement of the logs. When logs are lengthened by means of connectors, the joint should preferably be located at intersecting corners. Care should be taken to ensure sufficient lateral rigidity of the wall at the lengthening joints.

4. DESIGN PRINCIPLES FOR LOG STRUCTURES

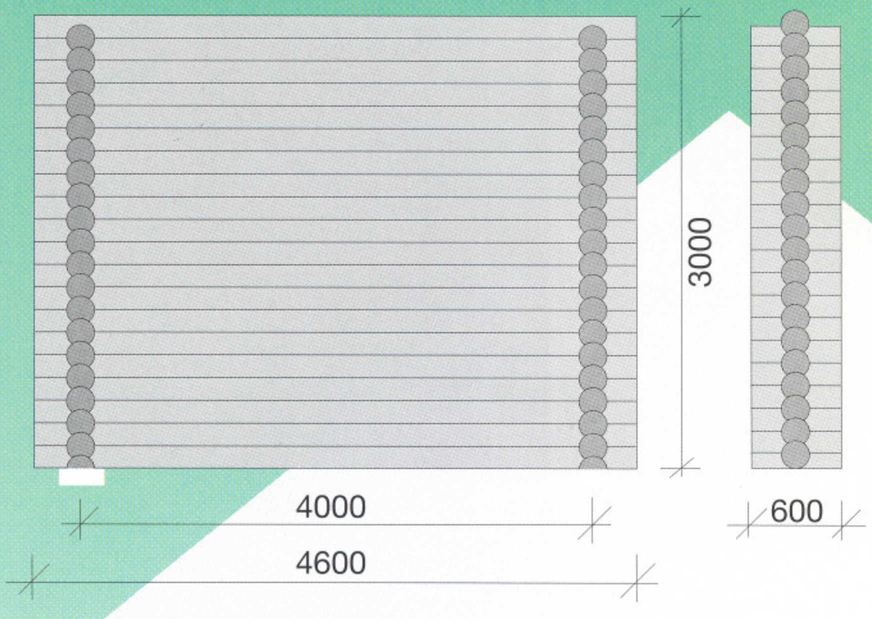
4.1 Load-bearing capacity

Directives concerning the timber structures used in buildings are presented in Section B10 of the National Building Code of Finland (Timber structures. Guidelines. 2001). The stress grade for round logs is T30. For rectangular logs, the stress grade, unless raised by sorting, is T24. Manufacture of glued and finger-jointed timber for use in load-bearing structures shall take place under quality control procedures approved by the Finnish Ministry of the Environment.

The loadings to be taken into account in the design of timber structures are classified on the basis of their duration into the following time classes: A – long-term, B – short-term, and C – instantaneous load. The design loading in the case of a log building generally falls within time class B.

When planning the structure, consideration is given to the moisture content of the wood, which depends on the relative humidity (RH) of the air surrounding the structure. Log structures are dimensioned according to moisture class 2, unless the structure has a higher than normal moisture content. In the case of class B load duration, the stress values allowed under moisture classes 1 (internally dry) and 2 (externally dry) are the same.

In a heated interior space, bending caused by the total load may not exceed a value of L/200 in the uppermost ceiling, or a value of L/300 in an intermediate or ground floor, where L is the length of span. Also, bending caused by the live load in the ground or intermediate floor must not exceed a value of 12 mm. The bending of cantilevers in relation to the length of span may be twice as much.



Recommendations for dimensioning the load-bearing capacity of log walls

The following dimensioning recommendations are based on log wall loading tests carried out by the VTT Technical Research Centre of Finland (Report No. RTE 3718/00) and the statement based on the tests.

1. The initial compression strength value is the smallest of the ultimate bearing stresses, i.e. 1.4 MPa. Based on this value, the specific bearing stress is $f_{c,90,k}$=1.0 N/mm².

2. The maximum wall height is 3 m.

3.The minimum log intersection length is 600 mm; however, lengths exceeding 600 mm are not utilized in calculations.

4. The maximum distance between log intersections is 8 m.

5. When the distance between log intersections is 4-8 m, the capacity of the wall is equal to the capacity of a 4 m long wall.

6. The thickness of a rectangular log is ≥ 70 mm and that of a round log ≥ 130 mm.

The above dimensioning recommendations can be expressed using the following formulae:

Log intersection:

$F_{log\ intersection} = f_{c,90,k} \cdot 600\ mm \cdot b_{ef}$

Where b_{ef} is
0.75 · wall thickness (rectangular log) and 0.5 · wall thickness (round log).

Wall log:

$F_{wall\ log} = f_{c,90,k} \cdot L \cdot b_{ef}$
when $L \le 4000$ mm
or

$F_{wall\ log} = f_{c,90,k} \cdot 4000 \cdot b_{ef}$
when 4000 mm < L < 8000 mm.

Wall with a log intersection:

$F_{wall} = 2 \cdot F_{log\ intersection} + F_{wall\ log}$

Example:
The thickness of the log wall with rectangular logs is 120 mm, the distance between log intersections is 5 m, and the height of the wall is 2.8 m. Log intersections are replaced by transversal walls.

$F_{wall} = 2 \cdot F_{log\ intersection} + F_{wall\ log}$

$= 2 \cdot f_{c,90,k} \cdot 600 \cdot 0.75 \cdot 120 + f_{c,90,k} \cdot 4000 \cdot 0.75 \cdot 120$
= 468000N = 468 kN

This is the calculated ultimate load of the wall under test conditions.

A. Eurocode 5
When dimensioning is based on the design standards of RIL-205, the partial safety factor is 1.3 for the material and 1.5 for the live load. For own weight, the value of 1.2 can be used. For example, when the time class of the load is intermediate, the factor (taking the time and moisture class into consideration) k_{mod} = 0.8 in moisture classes 1 and 2. This yields the nominal load ("permitted" load) affecting the wall as follows:

$F_k = (0.8 \cdot 468) : (1.5 \cdot 1.3) = 192$ kN.

Calculated per one length unit of the wall, this is

$q_k = 192 : 5 = 38.4$ kN/m

B. Limit state analysis
The limit state analysis (time class B, moisture class 1), using the time-effect factor of the material k = 1.3, yields the following calculated load:

$F_{wall} = 468 : 1.3 = 360$ kN.

Hence, $q_k = 360 : 5 = 72$ kN/m.

C. Permitted stresses
The calculation based on permitted stresses yields the following permitted load for the wall:

$F_{wall} = 360 : (1.3 \cdot 1.6) = 173$ kN.

Hence, $q_{perm} = 173 : 5 = 34.6$ kN/m.

4.2 Thermal insulation

Section C3 of the National Building Code of Finland (Thermal insulation. Regulations 1985. Available in English) lays down the requirements for thermal insulation.

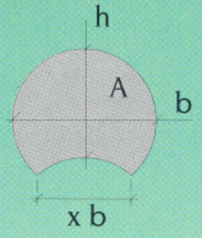
The individual k-value requirements for various components of residential buildings are as follows:

Outer wall	k-value ≤ 0.28 W/m²K
Uppermost ceiling	k-value ≤ 0.22 W/m²K
Ground floor	k-value ≤ 0.36 W/m²K (slab-on-ground)
	k-value ≤ 0.22 W/m²K (ventilated)
Door	k-value ≤ 0.7 W/m²K (unglazed part)
Window	k-value ≤ 2.1 W/m²K

Regulations governing thermal insulation also embody the so-called compensation principle. However, the k-value of an outer wall may not exceed 0.60 W/m²K with regard to compensating reductions in the k-values of other building components. The mean thickness of a solid log wall must be about 180 mm (λ_n = 0.12 W/mK) in order to meet the k-value requirement of 0.60 W/m²K.

For a round log wall, it is necessary to calculate a so-called geometric equivalent thickness, i.e. the thickness that corresponds to the thickness of a rectangular log wall with uniform thickness.

Geometric equivalent thickness
= A / h



h = diameter – height of recess
A = cross-section area of a round log
b = diameter
x b = width of recess

If the width of recess is assumed to be 0.5 b, the equivalent thickness is 0.855 b. With a recess width of 0.6 b, the equivalent thickness is 0.880 b.

If there is no vapour barrier installed, air will flow evenly through the seams of the log wall. The air passing through the log wall becomes warmer and the wall acts as an effective heat exchanger. This is referred to as thermal interaction. Research indicates that the total energy requirement can be significantly less than the separately estimated conduction and ventilation losses.

4.3 Moisture behaviour of log walls

Solid log walls

For moisture control, a solid log wall with no additional insulation is a safe and secure solution, provided that the building is equipped with proper structural protection. The moisture content of a log wall varies depending on the relative humidity of the air. At its maximum, the average variation is in the range of one percent (or slightly higher for smaller log thicknesses). The seasonal variation in the moisture content of wood is greatest in the layer extending to a depth of 5 cm from the internal and external surface of the log.

Log walls with additional insulation

The moisture control of a log wall with additional insulation is a far more complex issue.

Thermal insulation of the inside of the log wall is not recommended, unless a vapour barrier is installed. Internal thermal insulation without vapour barrier can be used, provided that the thickness of the insulation does not exceed 50 mm. In this case, the structure must contain bitumen paper or similar material serving as an air barrier. If the internal thermal insulation is thicker than 50 mm, it is necessary to use a sufficiently tight vapour barrier. If there is a ventilation gap between the insulation and the log, the thermal insulation properties inherent to the log cannot be exploited in the thermal insulation of the building.

Inverted structure (i.e. additional insulation on the outside) is problem-free as far as moisture control is concerned, because the log is then on the warmer and drier side of the structure. In this kind of a structure, it is necessary to have an air gap

Table 4.
Normative k-values (W/m²K) for wall structures with and without additional thermal insulation.
$\lambda_n = 0.12$ for the log; $\lambda_n = 0.037$ W/mK for the thermal insulation.
HH = rectangular log; Ø = round log

Log mm	Insulation (mm) 0	50	75	100	125	150
HH 70	1.28	0.47	0.36	0.29	0.24	0.21
HH 95	1.01	0.43	0.33	0.27	0.23	0.20
HH 120	0.83	0.39	0.31	0.26	0.22	0.19
HH 145	0.71	0.36	0.29	0.24	0.21	0.18
HH 170	0.62	0.34	0.27	0.23	0.20	0.18
HH 195	0.55	0.31	0.26	0.22	0.19	0.17
HH 220	0.49	0.30	0.25	0.21	0.18	0.16
Ø 130	0.89	0.40	0.32	0.26	0.22	0.19
Ø 150	0.79	0.38	0.30	0.25	0.22	0.19
Ø 170	0.71	0.36	0.29	0.24	0.21	0.18
Ø 190	0.64	0.34	0.28	0.23	0.20	0.18
Ø 210	0.59	0.33	0.27	0.23	0.20	0.17
Ø 230	0.54	0.31	0.26	0.22	0.19	0.17

AN EXAMPLE OF A COMPENSATION CALCULATION

Normally, a building covering a surface area of 100 m² has about 100 m² of ground floor, 100 m² of uppermost ceiling, about 80 m² of walls, about 15 m² of windows and about 5 m² of doors. The total surface area of the building envelope is thus about 300 m².
The average k-value for the whole envelope surface, calculated in accordance with the k-value requirements for various building components, should therefore not exceed 0.385 W/m²K.

$$k_{req} = \frac{115.4}{300} = 0.385 \text{ W/m}^2\text{K} \qquad k = \frac{115}{300} = 0.383 \text{ W/m}^2\text{K}$$

Building component	A m²	Requirement k_{req} W/m²K	A x k_{req} W/K	Selected structure k W/m²K	A x k W/K
Ground floor	100	0.36	36.0	0.23	23.0
Uppermost ceiling	100	0.22	22.0	0.15	15.0
Wall	80	0.28	22.4	0.60	48.0
Windows	15	2.10	31.5	1.70	25.5
Doors	5	0.70	3.5	0.70	3.5
Total	300		115.4		115.0

If the wall structure is constructed so that its k-value is as large as possible, i.e. k = 0.60 W/m²K, the other building components must be insulated to a correspondingly higher degree. For instance, by using windows with good insulation properties (k = 1.7 W/m²K) and by insulating the ground floor and the uppermost ceiling so that their respective k-values are 0.23 W/m²K and 0.15 W/m²K, it is possible to obtain an effective k-value of 0.383 W/m²K. In this way, the building will meet the thermal insulation requirements.

between the thermal insulation and the external cladding to allow the moisture possibly accumulating in the insulation to dry out. This also prevents the moisture penetrating through the cladding from reaching the thermal insulation.

4.4 Moisture proofing

Section C2 of the National Building Code of Finland (Humidity. Regulations and instructions.1998.) lays down the regulations for moisture control of buildings. The structures should be such that they are not detrimentally affected either by rainwater, snowmelt and ground moisture penetrating from the outside or water vapour originating within the building. Particular attention should be paid to the following points:

- Concrete may not be cast directly against wood without a moisture seal.
- The bottom of the log wall should be at least 400 mm above the surface of the ground.
- Showers and other water fixtures should not be installed on non-protected log walls.
- Water and moisture seals must be installed with particular attention and care, and in accordance with the manufacturer's instructions.

4.5 Fire resistance of log structures

Section E1 of the National Building Code of Finland (Structural Fire Safety. Regulations. 2002) contains fire safety regulations for buildings. A log is classified as combustible material. According to its surface-layer characteristics, it is classified into ignitability class 2 (the surface layer ignites slowly) and fire spreading class II (the surface layer spreads fire slowly). However, it must be borne in mind that the substructure and fixing also influence the classification.

The following codes are used to describe the requirements concerning building components:

R load-bearing capacity
E tightness
I insulation capacity

When a log wall is used as a compartmenting building component (E1), it is required that the fire resistance time of the log wall with different log thicknesses shall be verified by means of fire tests.

The load-bearing capacity in a fire situation is determined in accordance with the recommended dimensioning principles of Section B10 of the National Building code of Finland, as presented above in chapter 4.1.

4.6 Soundproofing of log walls

Factors governing the sound-insulation capacity of a log wall include its mass, its rigidity and the tightness of its seal recesses. The National Building Code of Finland does not lay down any requirements for the level of soundproofing of walls for detached houses. Walls in hotels and other public accommodation are subject to an airborne soundproofing requirement of 39…63 dB, depending on the nature of the spaces bounded by the walls. Log walls do not yield this level of airborne sound insulation, wherefore a composite structure (e.g. log + insulation + boarding) or other building materials must be used to yield the required level of soundproofing.

4.7 Building ventilation

Regulations governing ventilation are presented in Section D2 of the National Building Code of Finland (Indoor climate and ventilation in buildings. Regulations and guidelines1987. Available in English).

A satisfactory internal climate in spaces where people are normally present should be assured under all normal weather conditions and under the conditions of use particular to each space. The purity, temperature and humidity of the internal climate should be controlled. In places normally occupied by people, draughts and noise that would be detrimental to the comfort of the occupants are not permitted.

There must be adequate ventilation so that condensation of moisture in the structures will not cause moisture damage. Incoming air may be brought into a room space through the building's external envelope or as transferred air.

5. STORAGE AT THE WORK SITE

Timber can usually be stored outside, provided that it is protected against sunlight, rainwater and moisture from the ground. The goods stored outside must be at a height of at least 30 cm from the ground in order to prevent the ground moisture and vegetation from damaging the timber. To obtain sufficient stability and to prevent bending or warping due to storage, the dimension between the supporting boards should not exceed 1.5 metres. Care should be taken to prevent water from pooling below the timber. There should be a sufficient number of tarpaulins used in storage, because the transportation protection is not intended for long-term exposure to weather. The timber should be covered so as to be protected against rain, snow, dirt and direct sunlight. Transparent plastic is not an appropriate cover since it does not protect the wood from the effects of sunlight.

Timber should be covered so that air circulation is ensured. While the tarpaulin should expand over the ends of boards and logs, it must not reach the ground. When stacking timber, transversal battens between the bundles and logs should be used. This allows proper circulation of the air and conduction of excessive moisture.

6. CONDITIONS FOR THE ERECTION OF THE LOG FRAME

Packing material should not be allowed to get damp during the course of erection, since wet packing facilitates growth of fungi. Any pieces of packing that are exposed outside the seal recess should be cut away each working day, so as to avoid dampness.

The frame should be protected against persistent rain during construction. For long-term protection, and when the air is damp, care must be taken to maintain adequate ventilation under the tarpaulins.

Furthermore, particular attention must be given to ventilation once the erection work is completed, since moisture escaping from the structures may condense and cause, for instance, blue staining. The erection instructions provided by the manufacturer should be followed.

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HTT publications:
In co-operation with authorities, the Finnish Loghouse Industry Association (HTT) has published the following guidelines:

1. Hirsitalojen toimitusehdot ('Terms and conditions of delivery for log buildings'). Finnish Loghouse Industry Association (HTT), 3/2001.
2. Design principles for log buildings. Finnish Loghouse Industry Association (HTT), 3/2001.
3. Quality requirements for log buildings. Finnish Loghouse Industry Association (HTT), 3/2001.

The HTT has also published two books:

1. Hirsitalojen suunnittelu ('Design of log buildings'). Rakentajain Tietokirjat 3/2001
2. Hirsitalon rakentaminen ('Building a log house'). Rakentajain Tietokirjat 3/2001