Building physics

The thermal performance of a component is determined by its U-value or "thermal transmittance". The location, structure and thermal conductivity λ of the materials contained must be known to calculate this value. The thermal conductivity of wood is essentially determined by its bulk density and wood moisture content and can be calculated for a CLT panel using the equation below.

$\lambda = 0.000146 \times \rho_k + 0.035449$

λ = thermal conductivity in [W/mK]

ρ_K = characteristic bulk density for a reference wood moisture content of u = 12% in [kg/m³]

The characteristic bulk density of CLT layers has been determined as ρ_k = 512 kg/m³.
Applying these figures results in a thermal conductivity for CLT of 0.110 W/mK.

$\lambda = 0.000146 \times 512\ kg/m^3 + 0.035449 = 0.110\ W/mK$

This figure has been validated by the SP Technical Research Institute of Sweden for CLT [1].

The Austrian standard ÖNORM B 3012 [2] also gives a λ value of 0.11 W/mK for spruce.

An average value of 12 % is assumed for wood moisture content, whereby less than 12 % wood moisture content should be expected in external walls during the relevant winter months. With less wood moisture content, the actual thermal conductivity value reduces further.

The Austrian standard ÖNORM EN 12524 [3] specifies a rated thermal conductivity of 0.13 W/mK for wood in the relevant bulk density range.

U-value of a CLT panel

A CLT external wall panel with a thickness of 100 mm is used in the following example to demonstrate how to calculate the U-value. The calculation takes account of the internal and external heat transfer coefficients.

Thermal transmittance	$U = \frac{1}{R_{si} + \sum \frac{d_i}{\lambda_i} + R_{se}}$
Heat transmission resistance	$R_{si} = 0{,}13\ m^2K/W$ $R_{se} = 0{,}04\ m^2K/W$
Thermal conductivity of CLT	$\lambda_{CLT} = 0{,}11\ W/mK$
Thermal transmittance	$U_{CLT,100} = \frac{1}{0{,}13\ m^2K/W + \frac{0{,}1\ m}{0{,}11\ W/mK} + 0{,}04\ m^2\ K/W} = 0{,}927\ W/m^2K$

Fig. 1 shows a graph on which the U-values of non-clad CLT panels are plotted depending on panel thickness.

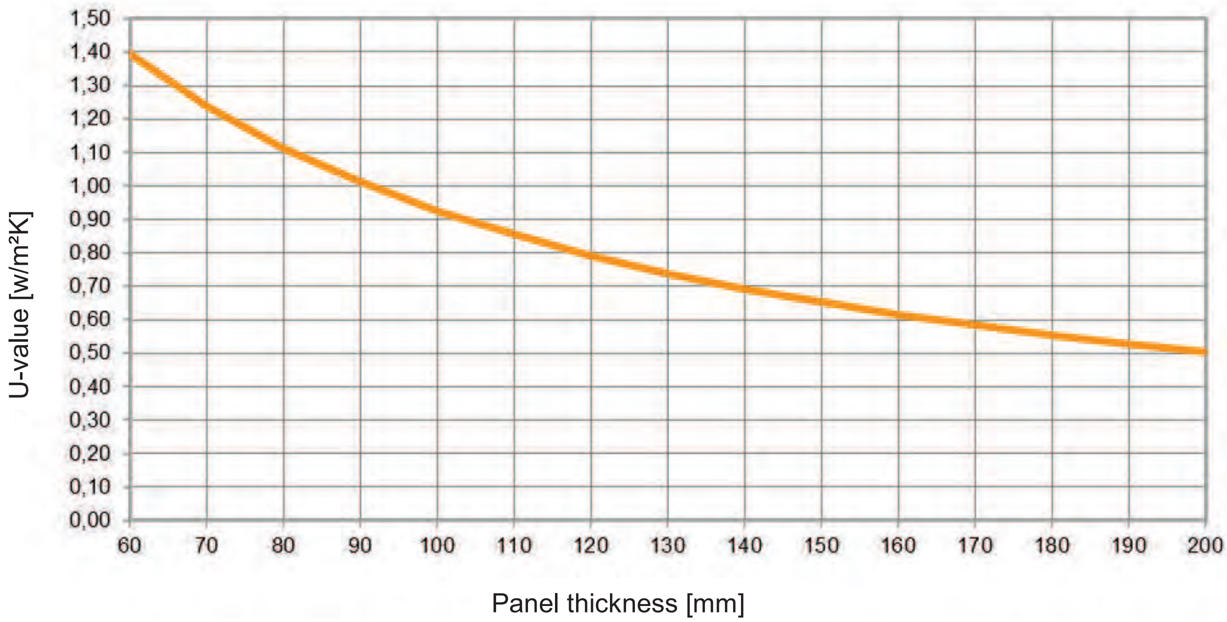


Fig. 1: U-values of non-clad CLT exterior wall panels

U-value of an insulated CLT panel

The U-value of a CLT panel with a thickness of 100 mm in conjunction with 16 cm-thick insulation material of thermal conductivity group WLG 040 is calculated as follows:

Thermal transmittance	$U = \dfrac{1}{R_{si} + \sum \dfrac{d_i}{\lambda_i} + R_{se}}$
Heat transmission resistance	$R_{si} = 0{,}13\ \boldsymbol{m^2 K / W}$ $R_{se} = 0{,}04\ \boldsymbol{m^2 K / W}$
Thermal conductivity of CLT	$\lambda_{CLT} = 0{,}11\ \boldsymbol{W / mK}$
Thermal transmittance	$U = \dfrac{1}{0{,}13\ m^2\,K/W + \dfrac{0{,}1\ m}{0{,}11\ W/mK} + \dfrac{0{,}16\ m}{0{,}04\ W/mK} + 0{,}04\ m^2 K/W}$ $= 0{,}197\ W/m^2K$

Fig. 2 shows a graph on which the U-values of insulated CLT panels with a thickness of 100 mm are plotted depending on the thickness of the insulation material (thermal conductivity group WLG 040).

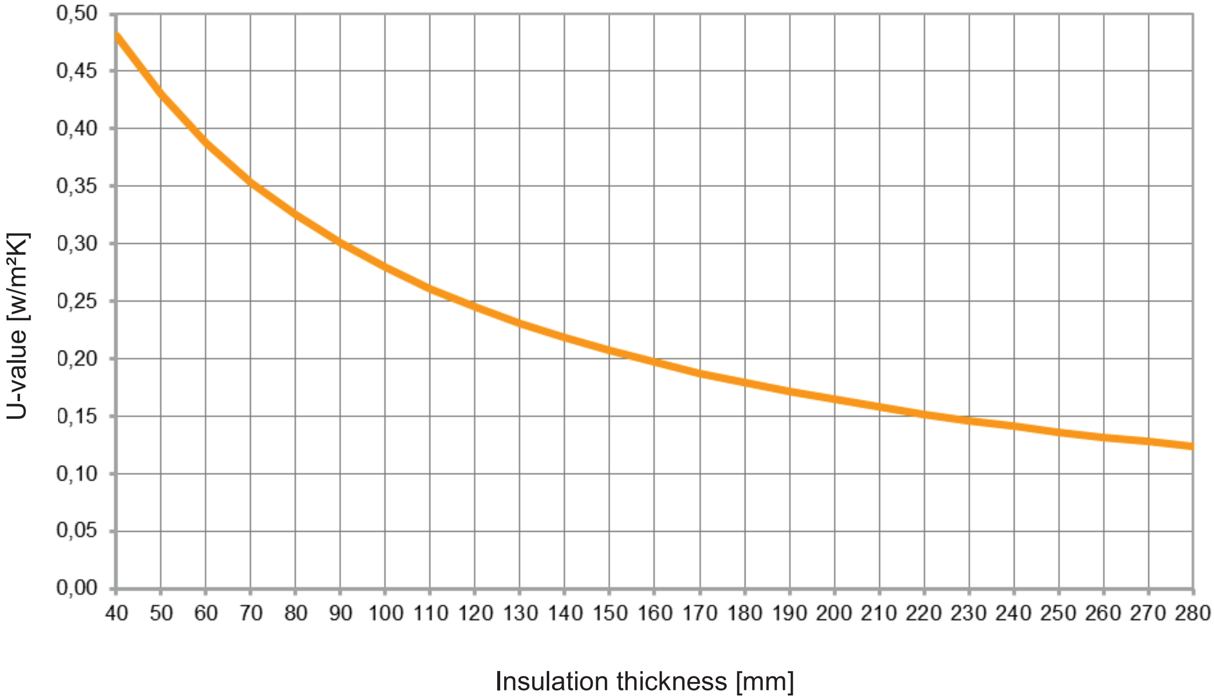


Fig. 2: U-values of insulated 100 mm CLT external wall panels depending on the thickness of the insulation (WLG 040 insulation material)

Airtightness

The air or convection tightness of a CLT panel is another decisive factor for thermal performance. As CLT panels are made of at least three bonded single-layer panels arranged at right angles to each other, they are extremely airtight. The airtightness of CLT panels and of panel joints was tested and confirmed by the Holzforschung Austria (Research Institute of the Austrian Society for Wood Research) in 2008 [4]. The test report specifies that the panel joints and the CLT panel itself are so airtight that volumetric rates of flow were outside the measurable range.

[1] Assessment: Declared thermal conductivity (2009-07-10); SP Technical Research Institute of Sweden, SE-50462 Boras

[2] ÖNORM EN B 3012 (2003-12-01); Wood species - Characteristic values for terms and symbols of ÖNORM EN 13556

[3] ÖNORM EN 12524 (2000-09-01); Building materials and products. Hygrothermal properties. Tabulated design values

[4] HOLZFORSCHUNG AUSTRIA (2008-06-11); Test report; airtightness test on a panel with two different types of joint

Building physics

U-VALUE - COMPARATIVE EXAMPLES 04/**2012**

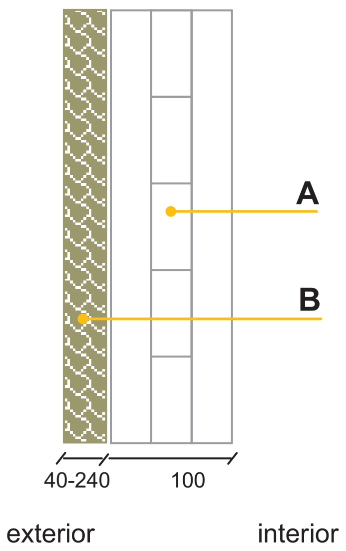
CLT solid wood panels

CLT 100 3s + WLG 040 insulation

Heat transmission values used:

Rsi	=	0.13 m² K/W
Rse	=	0.04 m² K/W

	Thickness [cm]	Building material [—]	λ [W/m²K]	Insulation thickness [cm]	Total thickness [cm]	U-value W/(m²K)
A	10	**CLT**	0.11	0	9.7	**0.95**
B	4-24	WLG 040 insulation	0.04	4	14	**0.48**
			0.04	6	16	**0.39**
			0.04	8	18	**0.32**
			0.04	10	20	**0.28**
			0.04	12	22	**0.25**
			0.04	14	24	**0.22**
			0.04	16	26	**0.20**
			0.04	18	28	**0.18**
			0.04	20	30	**0.16**
			0.04	22	32	**0.15**
			0.04	24	34	**0.14**



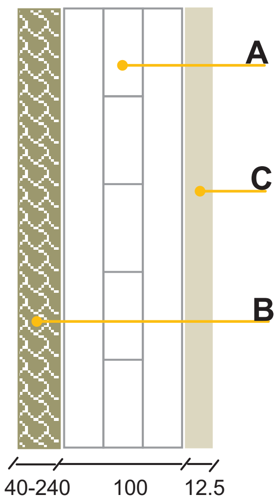
Building physics

CLT 100 3s + WLG 040 insulation + 12.5 mm plasterboard

Heat transmission values used:

Rsi	=	0.13 m² K/W
Rse	=	0.04 m² K/W

	Thickness [cm]	Building material [—]	λ [W/m²K]	Insulation thickness [cm]	Total thickness [cm]	U-value W/(m²K)
A	10	**CLT**	0.11	0	11	0.90
C	1.25	**Plasterboard**	0.21			
B	4-24	WLG 040 insulation	0.04	4	15	0.47
			0.04	6	17	0.38
			0.04	8	19	0.32
			0.04	10	21	0.27
			0.04	12	23	0.24
			0.04	14	25	0.22
			0.04	16	27	0.19
			0.04	18	29	0.18
			0.04	20	31	0.16
			0.04	22	33	0.15
			0.04	24	35	0.14



exterior interior

Building physics

U-VALUE - COMPARATIVE EXAMPLES 04/**2012**

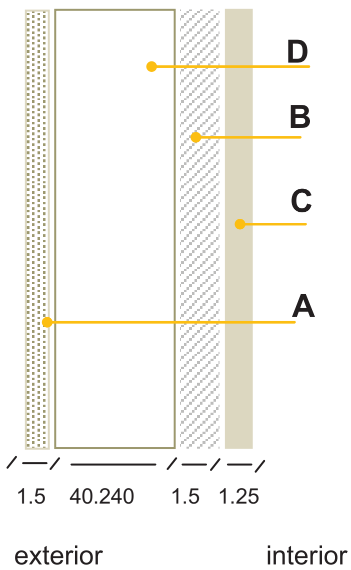
Timber frame building

Plasterboard panel, OSB board, WLG 040 insulation, upright, DHF (diffusible humid resistant fibreboard)

Calculated using solid wood uprights:

b	=	6 cm
e	=	62.5 cm
λ	=	0.13 W/(m²K)

	Thickness [cm]	Building material [—]	λ [W/m²K]	Insulation thickness [cm]	Total thickness [cm]	U-value W/(m²K)
A	1.5	**DHF**	0.12	1.5	--	--
B	1.5	**OSB board**	0.13	1.5	--	--
C	1.25	**Plasterboard**	0.21	1.25	--	--
D	4-24	WLG 040 insulation + construction timber	0.049	4	8	0.78
			0.049	6	10	0.59
			0.049	8	12	0.48
			0.049	10	14	0.40
			0.049	12	16	0.34
			0.049	14	18	0.30
			0.049	16	20	0.27
			0.049	18	22	0.24
			0.049	20	24	0.22
			0.049	22	26	0.20
			0.049	24	28	0.19

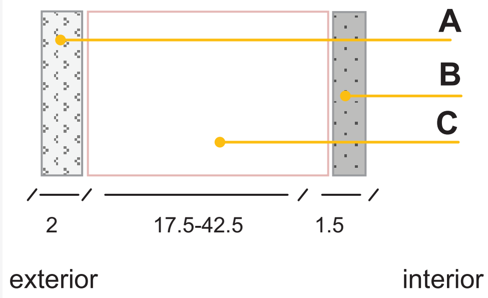


Building physics

Tile and insulation plaster

Lightweight mortar plaster, tile, lime plaster

NB: these values are taken from the company Wienerberger's brochure "POROTON 2011 product range" and relate to the "POROTON flat clay block" product range.

	Thickness [cm]	Building material [—]	λ [W/m²K]	Insulation thickness [cm]	Total thickness [cm]	U-value W/(m²K)
A	2	**Lightweight mortar plaster**	0.31	--	--	--
B	1.5	Lime plaster	0.7	--	--	--
C	4-24	Tile	0.16	17.5	21	**0.74**
			0.12	24	28	**0.44**
			0.1	30	34	**0.31**
			0.09	36.5	40	**0.23**
			0.09	42.5	46	**0.20**

Building physics

Contents:

1. Introduction

The airtightness and windtightness of the building envelope and of individual building components (wall, ceiling and roof panels) is an essential requirement which has an impact on many aspects of the indoor climate, noise load, freedom from structural defect, indoor atmosphere and energy balance of buildings.
Together, the airtight layer (generally on the inside of the room) and the windtight layer (on the outside of the building) prevent an inadmissible flow of air through the structure. These layers are critical to the quality and durability of the building structure [1].

CLT's tried and tested panel design results in an airtight layer. An additional airtight membrane on the inside of the room is not generally required. This has a positive effect on the associated costs, helps avoid errors and construction defects and also reduces construction times and installation phases.
With other timber construction methods (e.g. timber frame building), an airtight layer (at the same time also a vapour barrier in the form of a membrane or butt-bonded OSB boards) must also be provided.

2. Relevance of airtightness/windtightness

a) Airtightness:

Airtightness has an impact on the heat and humidity balance of a structure. The term "airtightness" refers to the prevention of convective flows, i.e. the penetration of structural components by air moving from inside to outside.

Inadequate airtightness can mean that air flows through the structure from inside to outside. The possible consequences are [1]:

- Deposition of condensation in the structure
- Reduced thermal protection
- Low surface temperature

The associated hazards are:

- Damage to the structure
- Mould formation
- Draughts (as a result of cooling of the indoor surface temperature)
- Increased energy demand

storaenso rethink.

Building physics

The airtightness of Stora Enso's CLT has been tested by the Holzforschung Austria.

This airtightness test on CLT was carried out on the basis of ÖNORM EN 12114:2000 [2] and covered the panel itself, a stepped rebate and a panel joint with a jointing board.

Outcome:

"The panel joints and the CLT panel itself exhibit a high level of airtightness. The volumetric flow rates through the two joint variants and through the undisturbed surface lay outside the measurable range as a result of the high level of impermeability" [3].

b) Windtightness:

The windtightness of a building envelope is just as relevant as its airtightness. Inadequate windtightness can result in similar phenomena to those occurring with inadequate airtightness. One of the reasons for this is the cooling of the insulating layer.

The windtight layer on the outside of the building prevents outside air from penetrating the building components. The insulating layer is therefore protected, and the building components' insulating properties are not impaired [1].

The relevance of windtightness is shown by means of the following illustrations (taken from [1]).

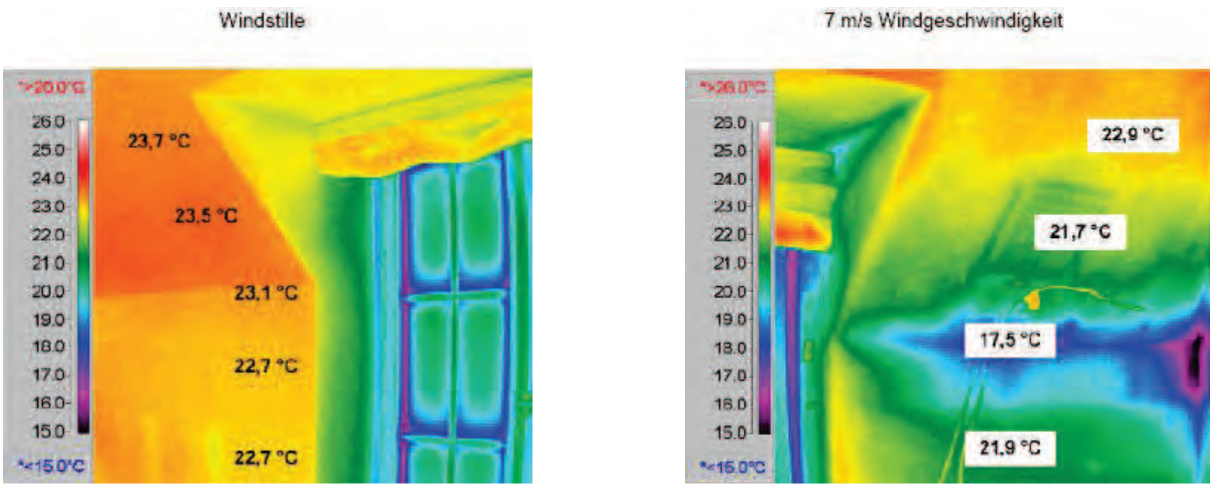


Illustration: Thermographic images of a wall/roof connection at + 3°C outdoor temperature and + 24°C indoor temperature (taken from [1])

3. Benefits of CLT with regard to airtightness

- Large-format panels (up to 2.95 m x 16 m) → therefore few building component joints and thus fewer joints to be sealed.
- As a rule, no additional membranes are required on the inside of the room.
- Simple, reliable joint or butt joint sealing by means of compressible preformed gasket is possible.

4. Technical aspects of airtightness

The air change rate (n_{50} value) is used to measure a building's airtightness.

Note:

Air change rate: The air change rate n (unit: 1/h) is used to describe ventilation. It indicates how often a room's air volume is changed per hour.

n_{50} value: The n_{50} value is the air change which occurs if 50 Pa (pascals) under or over pressure are generated in the building.

If all CLT connections (corner joints, side joints, windows etc.) are carried out properly, n_{50} values corresponding to the passive house standard (n_{50} = 0.6 1/h) can be achieved. ÖNORM B 8110-1: 2008 [4] specifies permissible air change rates. Depending on the building type, a distinction is drawn between buildings without ventilation systems (n_{50} = 3 1/h), buildings with ventilation systems (n_{50} = 1.5 1/h) and passive houses (n_{50} = 0.6 1/h) [4]. "Ventilation systems" refers to monitored ventilation systems for living spaces.

Compliance with these n_{50} values is vital for the function of the respective building envelopes.

The air change rate is measured and evaluated using the "blower door test".

This blower door test is recommended to the end customer by Stora Enso to enable the quality and construction of a building to be evaluated.

In addition to the issue of airtightness, the subject of vapour diffusion behaviour will also be examined briefly here:

CLT is an excellent material for wall structures which are membrane-free and which allow diffusion.

When no membrane is fitted, it is important to bear in mind that the vapour diffusibility of the individual layers (insulation, plaster, etc.) increases towards the outside (as a rule of thumb: the outer layer should exhibit up to ten times greater vapour diffusibility). This enables condensation to be avoided in wall, ceiling and roof structures.

Diffusion behaviour is expressed by means of the vapour diffusion resistance factor (□) and the air layer thickness (s_d value) equivalent of diffusion.

If the airtightness is inadequate, substantially higher levels of condensation can occur in the building components as a result of moist air flows through walls, ceilings and roofs than via condensation accumulating purely as a result of diffusion.

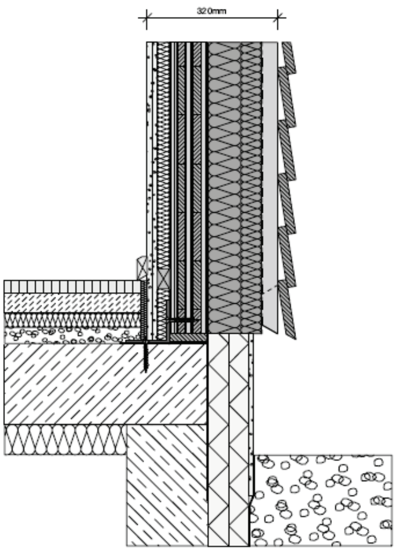
4. Configurations and specific connections

Compressed preformed gasket is mainly used to ensure an airtight seal at the connections of building components. Permanently flexible joint foams can also be used in some places. Self-adhesive tapes and tubular rubber seals are used more rarely (see item 4.g).

The configurations illustrated below show a few options for airtightness, though it should be noted that these are merely a few options among countless possible configurations [5], [6].

Building physics

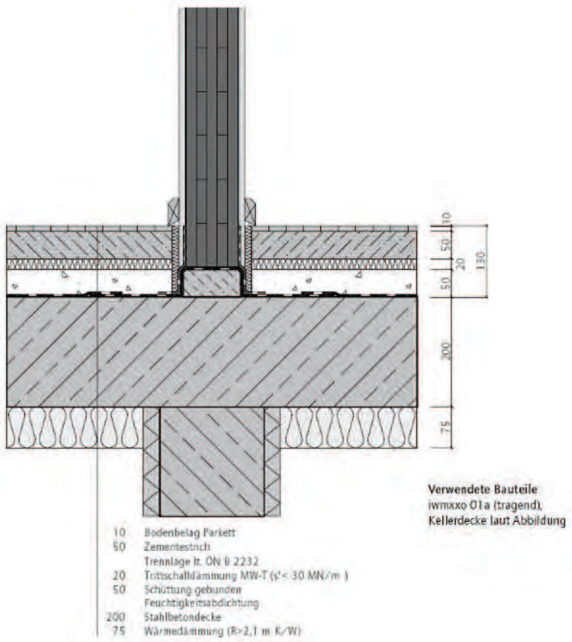
a) Plinth connection I



Connection of wall to cellar roof or concrete slab:

Another important factor in addition to air-tightness, is moisture protection in the plinth area.

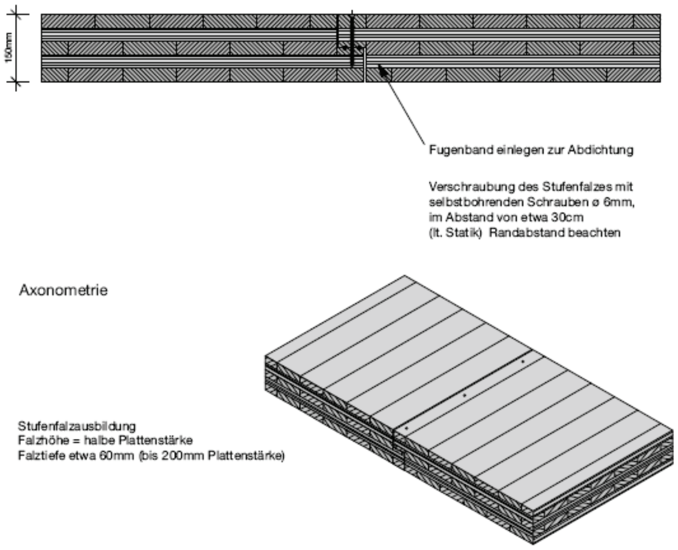
Plinth connection II



Connection of internal wall to cellar roof or concrete slab:

In this configuration the same criteria have to be applied as in the case of the connection between the wall and cellar roof or concrete slab.

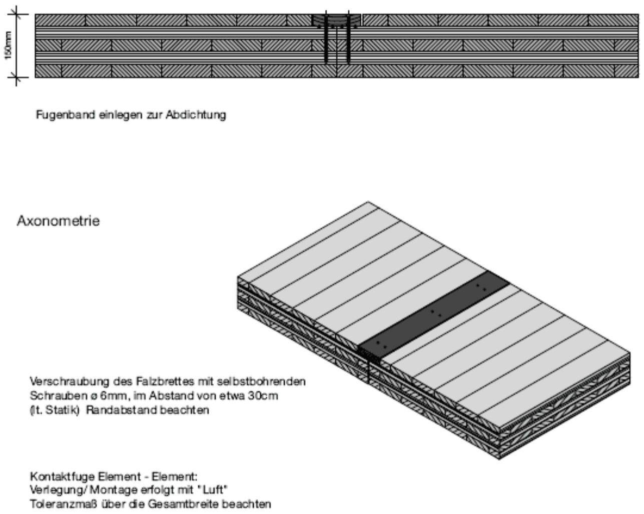
b) Wall and ceiling joint I



Stepped rebate connection:

Both the longitudinal and transverse seals of the stepped rebate are important (see illustration above).

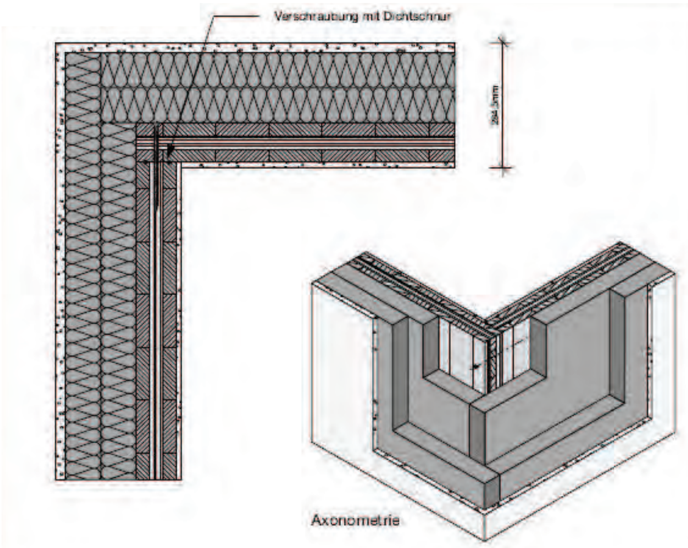
Wall and ceiling joint II



Jointing board connection:

The same procedure should be adopted for this connection as for a connection with a stepped rebate (see above).

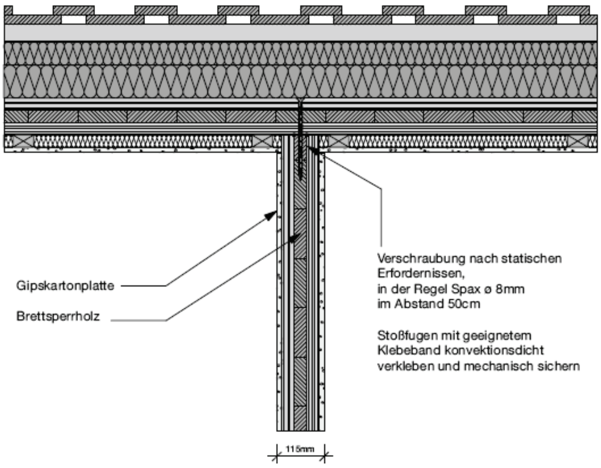
c) Wall connection I



Corner joint:

With all horizontal and vertical seals it is important to ensure a continuous joint seal (horizontal and vertical seals must be connected to each other).

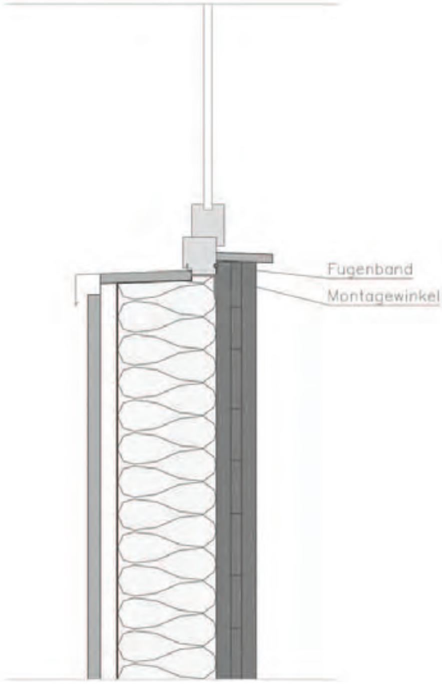
Wall connection II



Connection of longitudinal wall to transverse wall:

The same procedure as for a corner joint must be adopted here.

d) Window or door connection I

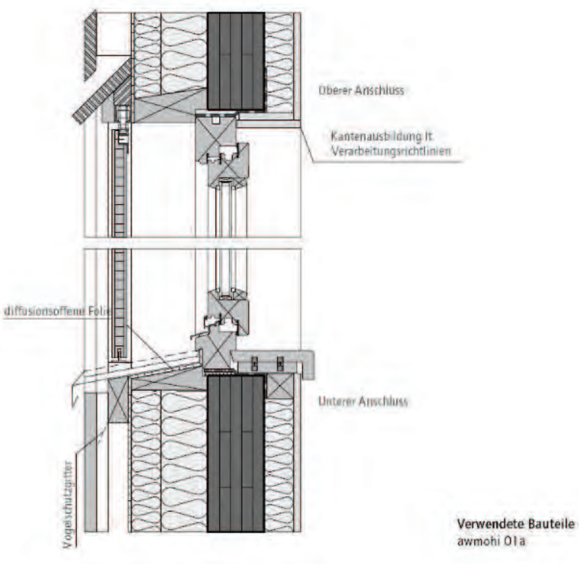


Connection of fitted window:

In this case the window frame is fitted on the CLT wall.

The window connection must be made using a suitable sealing system (wall gasket “Compriband”, joint tape etc.). It is important to ensure a proper, careful finish (precise corners etc.).

Window or door connection II

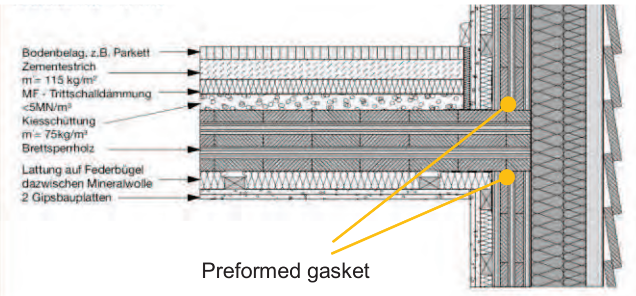


Connection of inserted window:

In this case the window frame is inserted into the CLT wall.

The window frame is inserted using wall gasket “Compriband” or a suitable PU foam. A soft-cell foam is recommended. It is important to ensure a proper, careful finish (precise corners etc.).

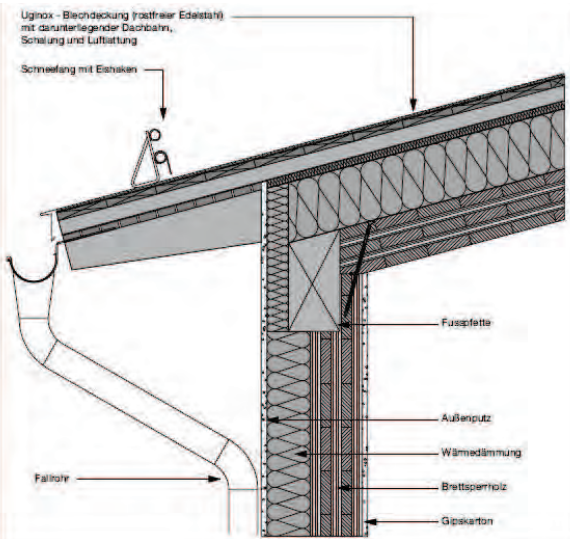
e) Wall/ceiling/wall connection



Connection of wall to ceiling:

The key contact surfaces are those of the upper and lower wall to the ceiling. Both contact surfaces must be connected so that they are airtight.

f) Wall/ceiling connection

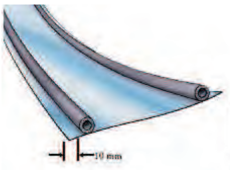


Connection of wall to roof panel or roof construction:

There are various ways of doing this. However, the wall panel should form a sealed unit with the roof panel.

All openings and apertures must be connected in an airtight manner to the relevant contact surfaces.

g) A few examples of materials for creating an airtight finish



EPDM seal

Sealing strip

Wall gasket “Compriband”

Self-adhesive tape

Appropriate materials must be used according to the requirements.

Self-adhesive tapes should be avoided due to areas which are difficult to access (corners, etc.).

Sources:

www.trelleborg.com
www.ramsauer.at
www.siga.ch

5. Summary

Both airtightness and windtightness are key requirements for a high-quality building made with CLT.

In the various connection configurations it is important to use a cohesive system with regard to airtightness and windtightness, i.e. all the horizontal and vertical joints must form a sealed unit.

Openings in the CLT structure should be avoided, or a professional, airtight finish must be made.

This is the only way to avoid increased heat loss with all its consequences such as penetration of moisture into the structure, mould fungus formation and so forth.

For further information:

www.clt.info

www.dataholz.com

6. Appendix

References:

[1] RICCABONA, CH. and BEDNAR TH. (2008):

Baukonstruktionslehre 4 [Building construction theory 4]; 7th edition; MANZ Verlag, Vienna

[2] ÖNORM EN 12114 (2000):

Thermal performance of buildings. Air permeability of building components. Laboratory test methods; Austrian Standards Institute, Vienna

[3] HOLZFORSCHUNG AUSTRIA (2008):

Test report; airtightness test on a panel with two different joint types

[4] ÖNORM B 8110-1 (2008):

Thermal protection in building construction. Requirements for thermal insulation and declaration of thermal protection of buildings and parts of buildings. Austrian Standards Institute, Vienna

[5] STEINDL R. (2007):

Degree dissertation; Structural components for houses made of cross-laminated timber

[6] www.dataholz.com

Internet, researched on 02.04.2009

Building physics

Contents:

1. Introduction

Structural components and parts of buildings are not only exposed to thermal stress, but also to hygric stress. After the building has been completed, building components often still contain a considerable amount of building moisture.
Therefore, using CLT is advantageous, as the driest possible structures can be obtained by using this product.

Building components must be sufficiently protected from all types of moisture. Excessive moisture content can **reduce solidity and thermal insulation**. At the same time however, wood requires a minimum level of moisture (particularly in the case of visible panels) in order to reduce drying cracks.

Figure 1 shows the different effects of moisture which a building must be protected from.

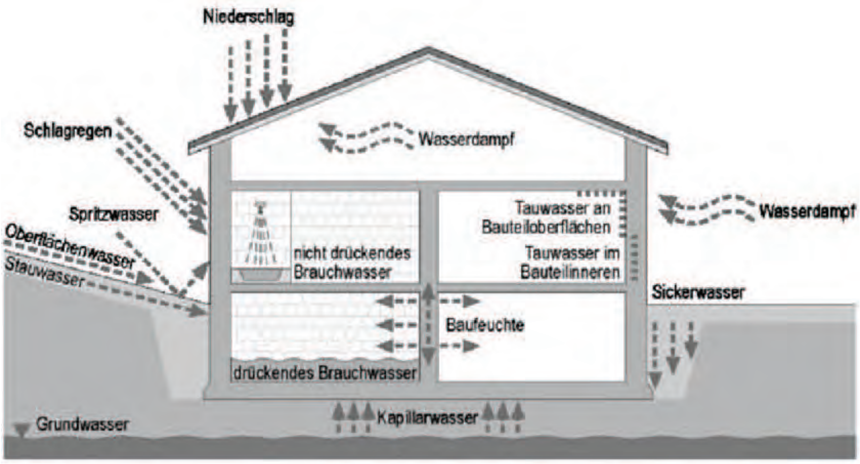


Fig. 1: Typical moisture conditions of a building (Fischer *et al.*, 2008)

As the load-bearing structure and the insulation layer are clearly separate on CLT panels, the structural and physical aspects of the design can be considered separately. CLT offers a further advantage in that, besides the load-bearing structure, it also has a significantly higher thermal mass in comparison to other wood construction systems. With 3 layers and more, CLT panels are airtight.

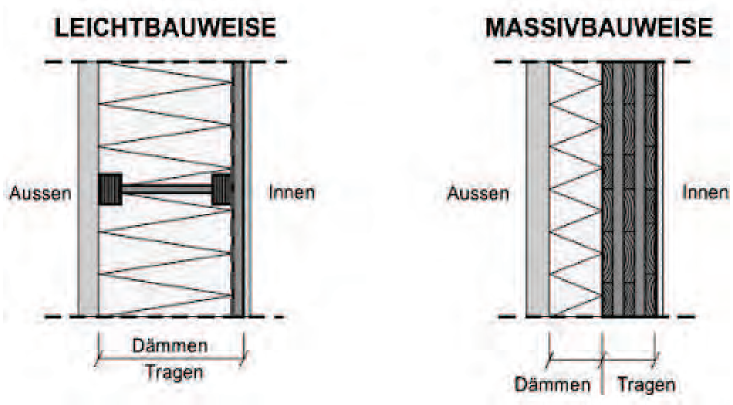


Fig. 2: Comparing lightweight wood construction with solid wood construction (Graz Technial University, 2008)

2. Reasons for moisture protection

For building owners and occupants, moisture protection is necessary or advisable for the following reasons:

a) Room usability

Rooms require a precisely defined indoor climate which means that uncontrolled levels of humidity must be avoided. Damp building materials can be the source of germs and odorous substances.

b) Building heat insulation

Increased moisture in the building means that the thermal conductivity of the building's materials increases and more energy is required to heat the building. More energy is also required to remove damp air and condensation.

c) Preserving the building structure

Managing a building's exposure to moisture is essential for preserving the building's structure. Most structural damage can be traced back to the impact of water.

3. Diffusion

Diffusion is the movement of tiny single particles (atoms, ions, molecules), caused by the thermal self-motility (Brownian motion) of these tiny particles.

In the same way as heat flow, water vapour also flows

- according to the drop in temperature from warm to cold or
- according to relative humidity from moist air to dry air.

This diffusion flow occurs in the air and also in porous building components containing air pockets. The more impermeable a building component, the greater its diffusion resistance. Damp materials are more permeable to water vapour diffusion.

4. Diffusion resistance factor and s_d value

a) Diffusion resistance factor

The water vapour diffusion resistance factor μ is used to measure the impermeability of a building material to diffusing water molecules. μ is a dimensionless quantity which indicates the factor by which a material's diffusion resistance increases in comparison to the reference value. Air is used as the reference value as it generally offers the least resistance to water vapour (μ = 1).

Only glass and metal can be considered impermeable to water vapour; all other materials are permeable to water vapour, even if diffusion resistance can be very high.

b) s_d value

The diffusion resistance factor μ alone is not enough to identify the impermeability to water vapour diffusion of a layer of material, rather than of the material itself. Both the type of material and the thickness of the layer must be known to understand the extent of resistance to water vapour diffusion.

Thus, the simplest definition to describe the resistance of a layer of material is derived from the product of the thickness of the layer and the diffusion resistance factor. Therefore, in building physics, the term "equivalent air layer thickness s_d" is used to measure the diffusion resistance of a layer of material.

$$s_d = \mu * d$$

The s_d value represents how thick a layer of air must be to have the same transmission resistance as the component.

CLT panels have different levels of diffusion resistance. This depends on the lamella thickness and the number of layers and adhesive joints.

$$\sum s_d = \mu_1 * d_1 + \mu_2 * d_2 + \mu_3 * d_3 + \ ... + \mu_n * d_n$$

5. Holzforschung Austria's expert opinion

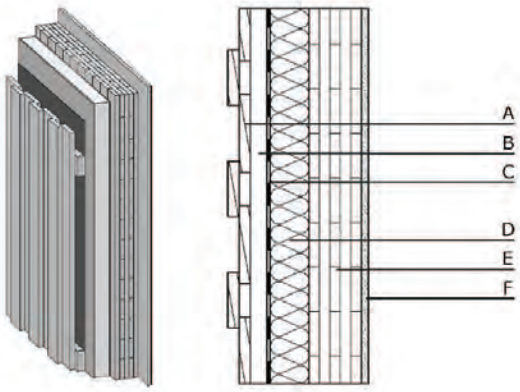
Holzforschung Austria's expert opinion reveals that:
A 3-layer CLT panel exhibits the same s_d value as that of a solid wood panel made of spruce with similar strength (+ 26 mm for the bonded joint on the CLT panel).

- Dependence of the material moisture content

  The bonded joint's μ value significantly decreases in damper test conditions. Porous cavities occur between the adhesive layers and capillary contacts between end grain and length grain wood. This enables faster moisture transport processes in humid climates compared with dry climates. However, this depends on the type of adhesive and the relative ambient humidity.

- The s_d value should be 5–10 m lower towards the surface than on the inside. By way of example:

  Standard wall structure with ventilated façade



Baustoffangaben zur Konstruktion, Schichtaufbau
(von außen nach innen, Maße in mm)

	Dicke	Baustoff	Wärmeschutz				Brandverhaltenskl..
			λ	μ min – max	ρ	c	EN
A	20,0	Holz Lärche Außenwandverkleidung	0,150	50	600	1,600	D
B	30,0	Holz Fichte Lattung	0,130	50	500	1,600	D
C		diffusionsoffene Folie sd ≤ 0,3m					
D	50,0	Holzwollemehrschichtplatte (WW-MW-WW)	0,049	2 - 5	130	1,000	B
E	78,0	Massivholz verleimt (z.B. Brettsperrholz 3-lagig)	0,130	50	500	1,600	D
F	13,0	Gipsfaserplatte od. 12,5 mm GKF	0,320	21	1000	1,100	A2

Plasterboard: s_d = 0.273 m; cross-laminated timber: s_d = 3.9 m; insulation: s_d = 0.25 m; permeable layer: $s_d \leq 0.3$ m
The structure is more impermeable towards the surface (calculated using the cross-laminated timber) and is therefore correct from a building physics point of view.

6. Significance of moisture and diffusion for CLT

With 3 layers and more, CLT panels are "airtight" but not vapour proof. This means that CLT is permeable and the adhesive bonds form vapour barriers for the insulation plane. Just like any other construction system, CLT must be protected from permanent moisture.

CLT regulates the inside air. When there is higher ambient humidity, CLT absorbs the moisture and releases it again when the level of humidity decreases.

CLT can also be described as a moisture variable vapour barrier. It is more permeable in the summer, when temperatures are high and the air humid, than in the winter when temperatures are cold and the air is drier.

8. Sources

HOLZFORSCHUNG AUSTRIA:

Test report/expert opinion, diffusion measurement performed in July 2009

FISCHER, H., FREYMUTH, H., HÄUPL, P. ET AL. (2008):

Lehrbuch der Bauphysik [Building physics text book]. 6th completely revised edition, publishers: Vieweg + Teubner Verlag, Wiesbaden

HÄUPL, P. (2008):

Bauphysik: Klima, Wärme, Feuchte, Schall [Building physics: climate, heat, humidity, sound]. Publishers: Ernst & Sohn Verlag, Berlin

RICCABONA, C., BEDNAR, T. (2008):

Baukonstruktionslehre [Construction method] 4; 7th completely revised edition, publishers: MANZ Verlag, Vienna

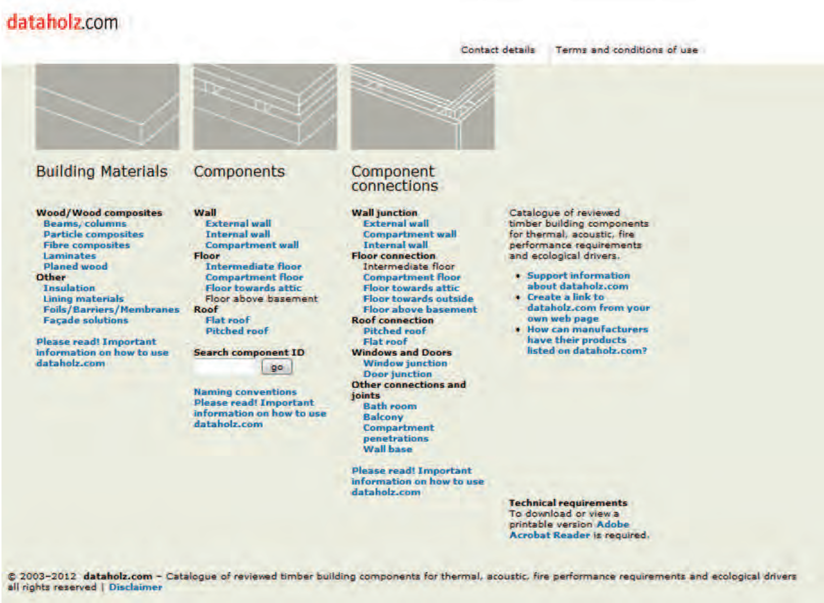
Solid wood is more fire resistant than is generally assumed. CLT has a moisture content of approx. 12%. Before wood can catch fire, the water it contains must first evaporate. A carbonised surface protects the internal CLT layers so that—unlike steel or concrete constructions—solid wood constructions in a fire are charred on the surface but do not burn right through.

To support this statement, we asked an accredited institute—the Holzforschung Austria—to test how fire resistant our CLT solid wood panels actually are. The results speak for themselves and even exceeded our expectations.

The abridged report can be downloaded from **www.clt.info**.

Building physics

In addition to the following reviews on the subject of sound insulation, Stora Enso recommends the website www.dataholz.com.



Building physics

The following evaluations with regard to building physics were performed by the European accredited institute HFA — Holzforschung Austria — and contain the following tested components:

1. **External walls**
2. **Internal walls**
3. **Partition walls**
4. **Ceilings**
5. **Roofs**

Issued on: 12.01.2012 **Order number:** 2177/2011 – BB **Version:** 1.0

During the evaluations, the following sources were referred to:

Fire resistance

ÖNORM EN 13501-2 Fire classification of construction products and building elements — Part 2: Classification using data from fire resistance tests, excluding ventilation services.

Preliminary proceedings for determining heat insulation characteristics

ÖNORM B 8110-6, Thermal protection in building construction — Part 6: Principles and verification methods — Heating demand and cooling demand. Version: January 2010

ÖNORM EN ISO 6946, Building components — Thermal resistance and thermal transmittance — Calculation method, version: April 2008

ÖNORM B 8110-2, Thermal insulation in building construction — Part 2: Water vapour diffusion and protection against condensation, version: July 2003

ÖNORM EN ISO 13788, Hygrothermal performance of building components and building elements — Internal surface temperature to avoid critical surface humidity and interstitial condensation — Calculation methods, version: January 2002

ÖNORM B 8110-3, Thermal protection in building construction — Part 3: Heat storage and solar impact, version: December 1999

ÖNORM EN 12524; Building materials and products — Hygrothermal properties — Tabulated design values, version September 2000

Noise assessment

The assessed standard sound level difference was determined using comparable components investigated with regard to the level of protection against airborne noise to be achieved and taking the relevant technical literature into account. In particular, the parts catalogue “dataholz.com — Catalogue of the physical and ecological properties of inspected wood components”, version: 2003, ÖNORM B 8115-4 Sound insulation and room acoustics in building construction — Measures to fulfil the requirements on sound insulation, version: 2003, and Timber construction manual, number 3, part 3, series 4 “Sound proofing — Walls and Roofs” by the Timber Information Service, version: 2003 and Timber construction manual, number 3, part 3, series 3 “Sound-absorbing wooden beams — and Brettstapel ceilings” by the Timber Information Service and “Sound-absorbing exterior components made of wood” by ift Rosenheim Centre for Acoustics (LSW), final report 2004.

External walls

Building physics

Component	Façade	Insulation material	CLT	Interior work
1.1	Plaster	EPS	CLT 100 C3s	CLT visible quality
1.2	Plaster	EPS	CLT 120 C3s	CLT visible quality
1.3	Plaster	EPS	CLT 100 C3s	Panelled with GKF plasterboard
1.4	Plaster	EPS	CLT 120 C3s	Panelled with GKF plasterboard
1.5	Plaster	EPS	CLT 100 C3s	Facing with GKF plasterboard
1.6	Plaster	EPS	CLT 120 C3s	Facing with GKF plasterboard
1.7	Plaster	Mineral wool	CLT 100 C3s	CLT visible quality
1.8	Plaster	Mineral wool	CLT 120 C3s	CLT visible quality
1.9	Plaster	Mineral wool	CLT 100 C3s	Panelled with GKF plasterboard
1.10	Plaster	Mineral wool	CLT 120 C3s	Panelled with GKF plasterboard
1.11	Plaster	Mineral wool	CLT 100 C3s	Facing with GKF plasterboard
1.12	Plaster	Mineral wool	CLT 120 C3s	Facing with GKF plasterboard
1.13	Plaster	Softboard	CLT 100 C3s	CLT visible quality
1.14	Plaster	Softboard	CLT 120 C3s	CLT visible quality
1.15	Plaster	Softboard	CLT 100 C3s	Panelled with GKF plasterboard
1.16	Plaster	Softboard	CLT 120 C3s	Panelled with GKF plasterboard
1.17	Plaster	Softboard	CLT 100 C3s	Facing with GKF plasterboard
1.18	Plaster	Softboard	CLT 120 C3s	Facing with GKF plasterboard
1.19	Timber	Softboard	CLT 100 C3s	CLT visible quality
1.20	Timber	Softboard	CLT 120 C3s	CLT visible quality
1.21	Timber	Softboard	CLT 100 C3s	Panelled with GKF plasterboard
1.22	Timber	Softboard	CLT 120 C3s	Panelled with GKF plasterboard
1.23	Timber	Softboard	CLT 100 C3s	Facing with GKF plasterboard
1.24	Timber	Softboard	CLT 120 C3s	Facing with GKF plasterboard
1.25	Timber	Mineral wool	CLT 100 C3s	CLT visible quality
1.26	Timber	Mineral wool	CLT 120 C3s	CLT visible quality
1.27	Timber	Mineral wool	CLT 100 C3s	Panelled with GKF plasterboard
1.28	Timber	Mineral wool	CLT 120 C3s	Panelled with GKF plasterboard
1.29	Plaster	Mineral wool	CLT 120 C3s	Facing with GKF plasterboard

rethink.

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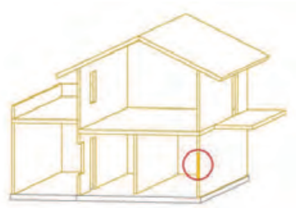
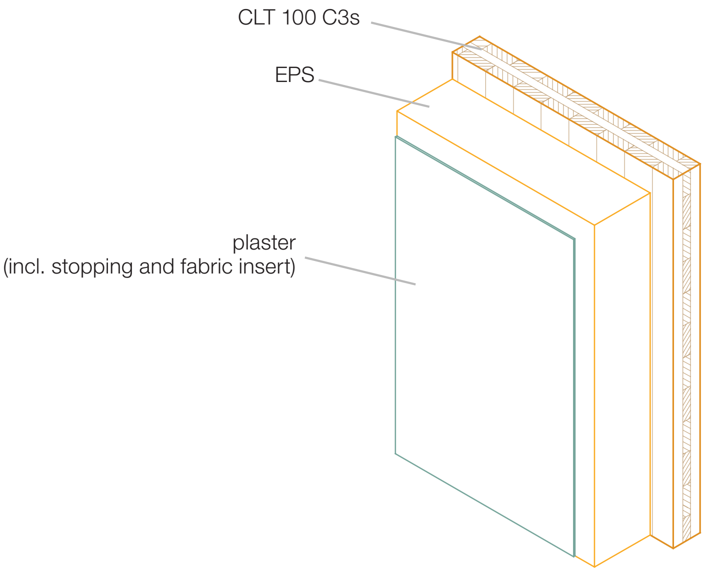
Building physics

1.1 External wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
EPS	16, 20, 26	0.031	60	18	E
CLT 100 C3s	10	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.16	adequate	34.7	36	
20	REI 60	35	0.13	adequate	34.8	36	
26	REI 60	35	0.11	adequate	34.9	36	

rethink.
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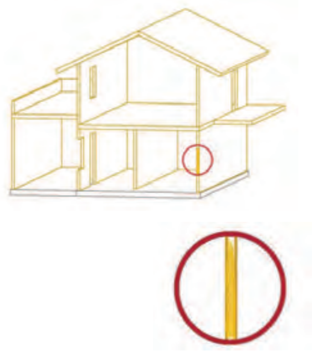
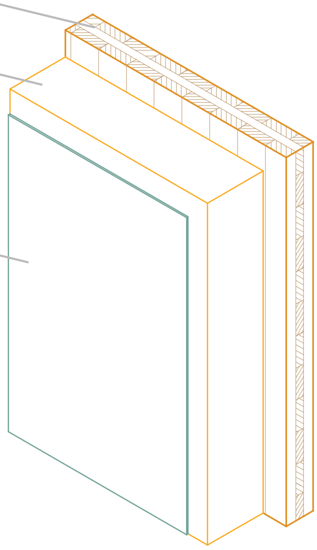
1.2 External wall

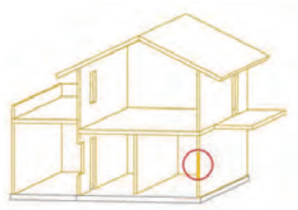


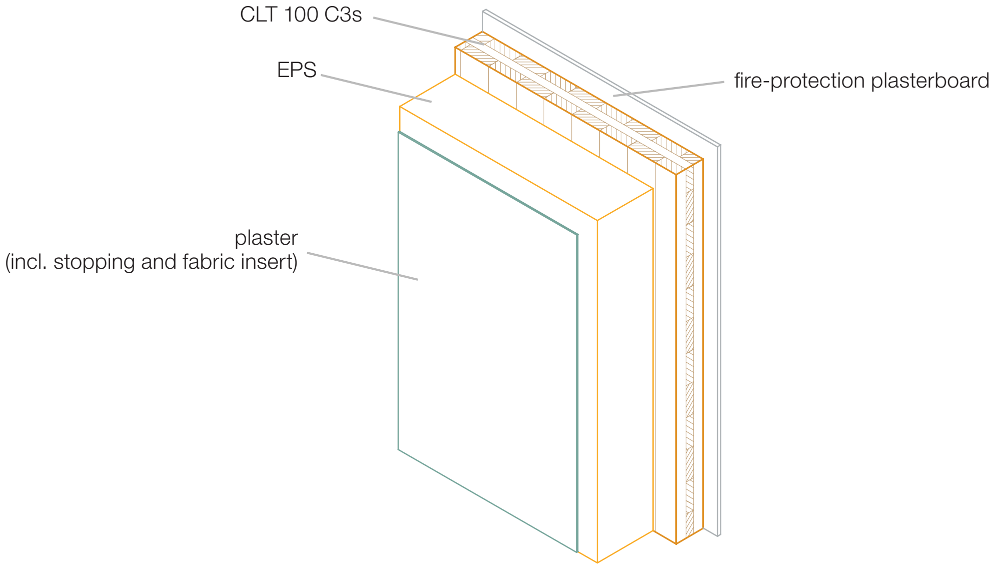


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
EPS	16, 20, 26	0.031	60	18	E
CLT 120 C3s	12	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.16	adequate	33.3	36	
20	REI 60	35	0.13	adequate	33.4	36	
26	REI 60	35	0.10	adequate	33.4	36	

1.3 External wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
EPS	16, 20, 26	0.031	60	18	E
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.16	adequate	38.7	37	
20	REI 90	35	0.13	adequate	38.8	37	
26	REI 90	35	0.11	adequate	38.8	37	

rethink.

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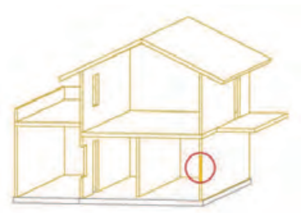
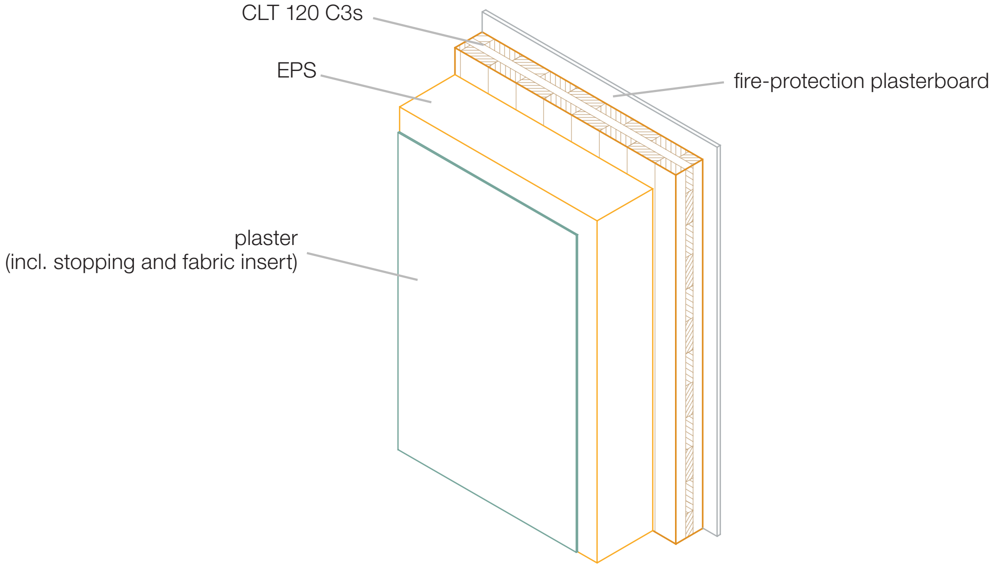
1.4 External wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
EPS	16, 20, 26	0.031	60	18	E
CLT 120 C3s	12	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.15	adequate	37.4	37	
20	REI 90	35	0.13	adequate	37.4	37	
26	REI 90	35	0.10	adequate	37.4	37	

rethink.
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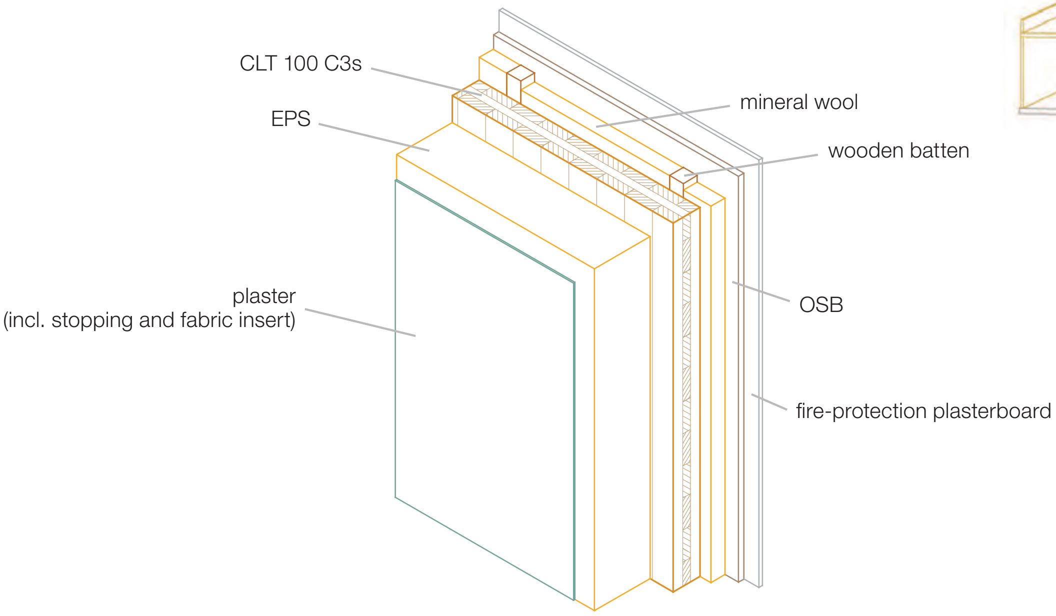
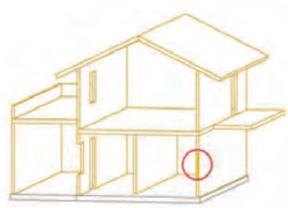
1.5 External wall

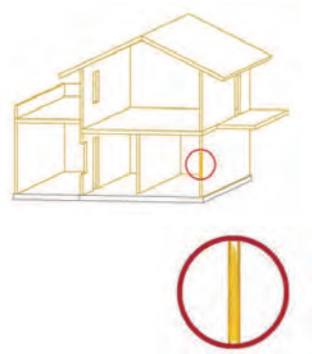


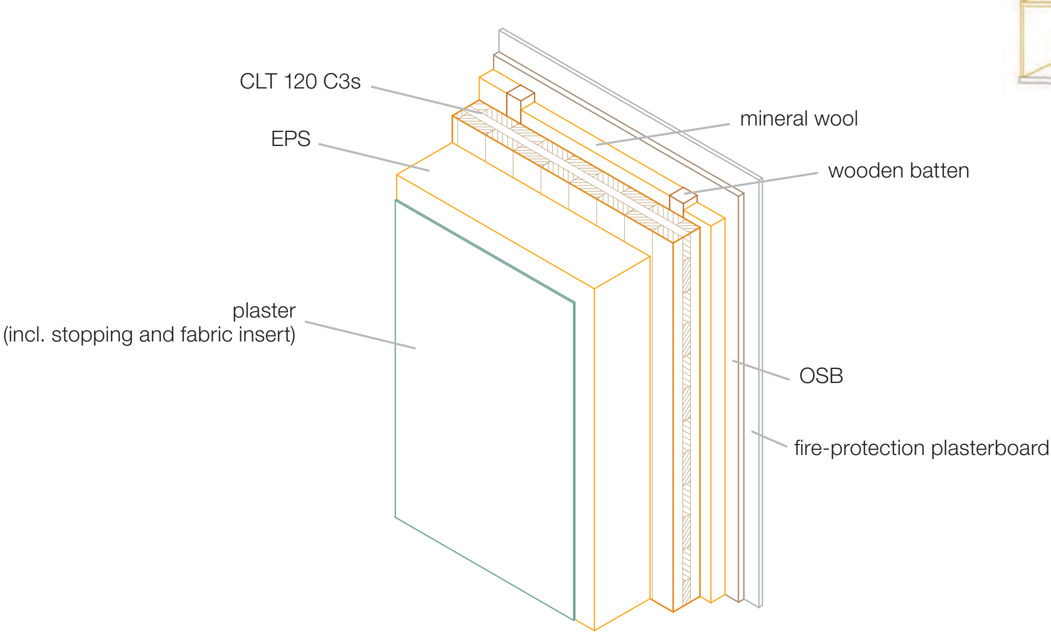


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
EPS	16, 20, 26	0.031	60	18	E
CLT 100 C3s	10	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
OSB	1.5	0.130	200-300	600	B
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 120	35	0.13	adequate	27.2	43	
18	REI 120	35	0.12	adequate	27.2	43	
20	REI 120	35	0.11	adequate	27.2	43	
26	REI 120	35	0.09	adequate	27.2	43	

1.6 External wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
EPS	16, 20, 26	0.031	60	18	E
CLT 120 C3s	12	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
OSB	1.5	0.130	200-300	600	B
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 120	35	0.13	adequate	27.2	43	
20	REI 120	35	0.11	adequate	27.2	43	
26	REI 120	35	0.09	adequate	27.2	43	

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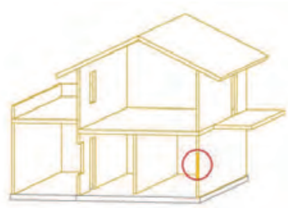
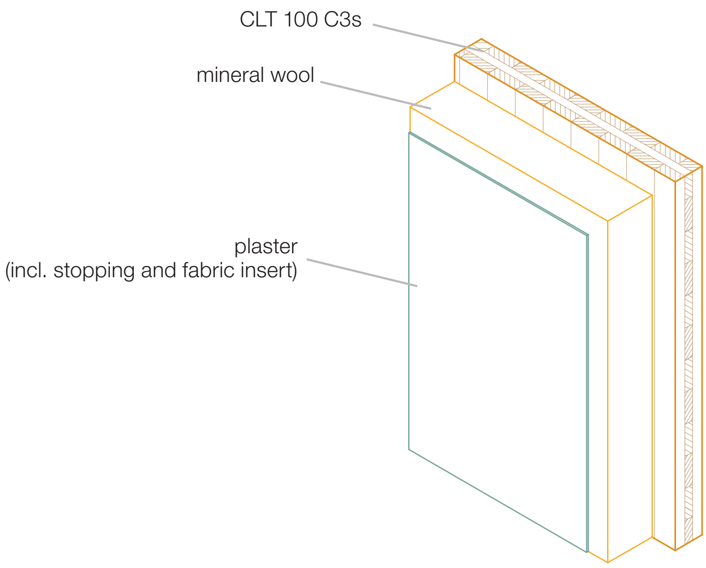
1.7 External wall

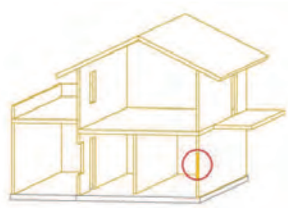


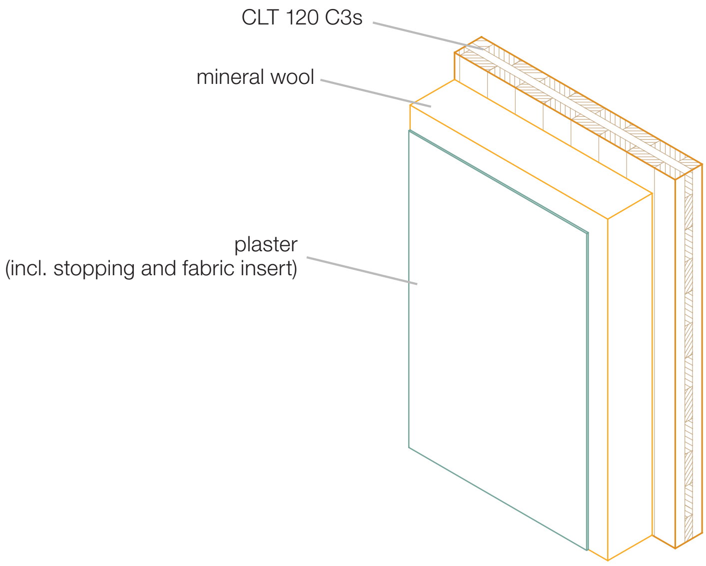


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Mineral wool	16, 18	0.035	1	18	A1
CLT 100 C3s	10	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.18	adequate	34.7	38	
18	REI 60	35	0.16	adequate	34.7	38	

1.8 External wall

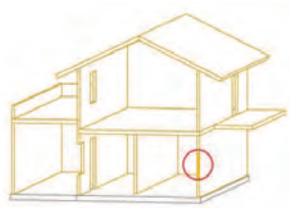


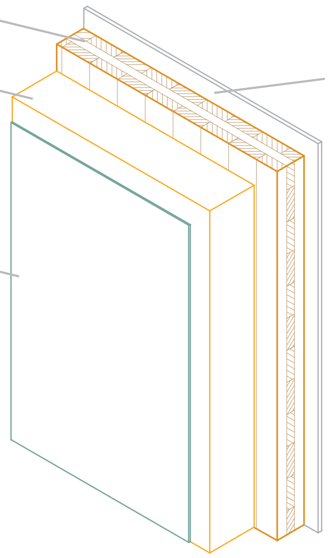


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Mineral wool	16, 18	0.035	1	18	A1
CLT 120 C3s	12	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.17	adequate	33.3	38	
18	REI 60	35	0.16	adequate	33.3	38	

1.9 External wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Mineral wool	16, 18	0.035	1	18	A1
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.18	adequate	38.7	39	
18	REI 90	35	0.16	adequate	38.7	39	

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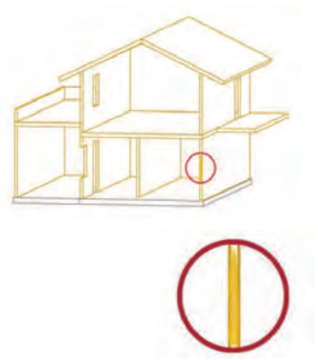
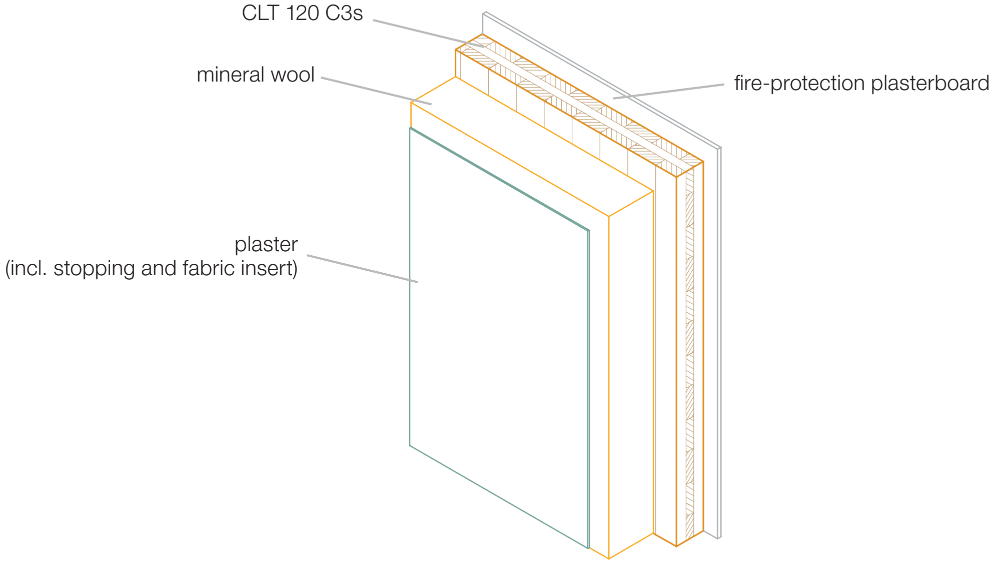
1.10 External wall



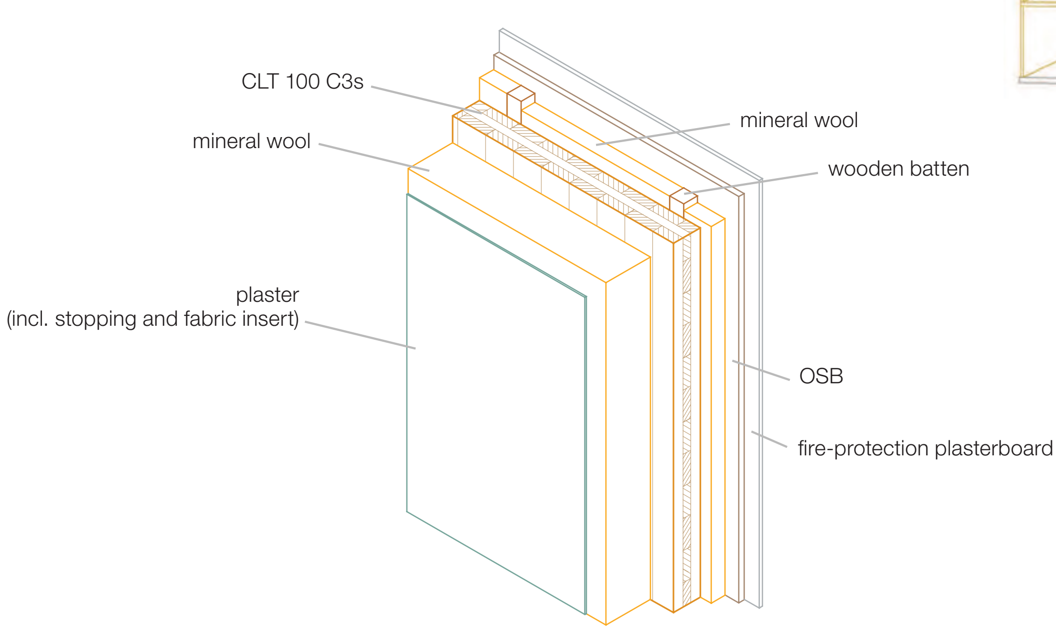


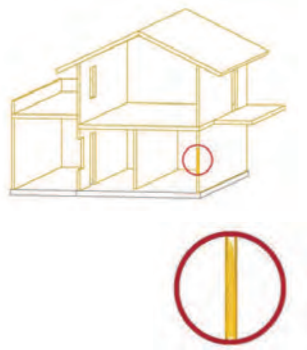
Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Mineral wool	16, 18	0.035	1	18	A1
CLT 120 C3s	12	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.17	adequate	37.4	39	
18	REI 90	35	0.16	adequate	37.4	39	

Building physics

1.11 External wall





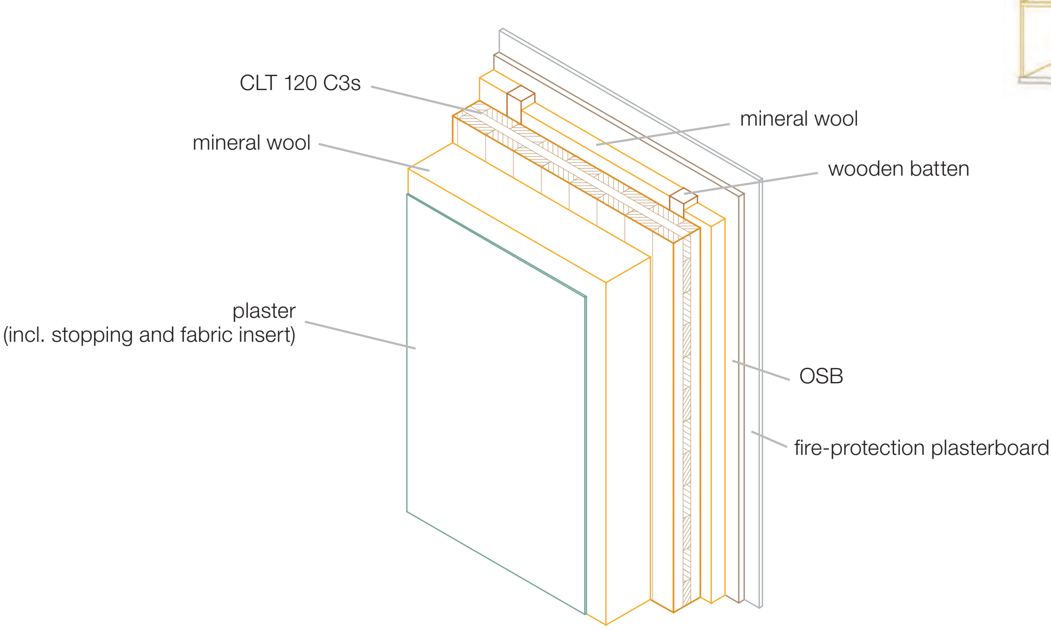
Component design

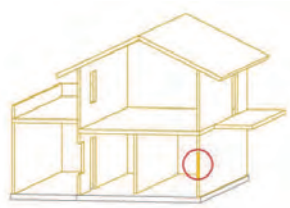
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Mineral wool	16, 18	0.035	1	18	A1
CLT 100 C3s	10	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
OSB	1.5	0.130	200-300	600	B
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 120	35	0.14	adequate	27.2	45	
18	REI 120	35	0.13	adequate	27.2	45	

1.12 External wall





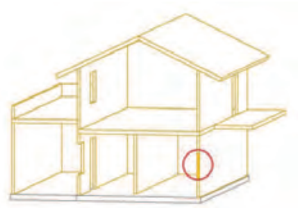
Component design

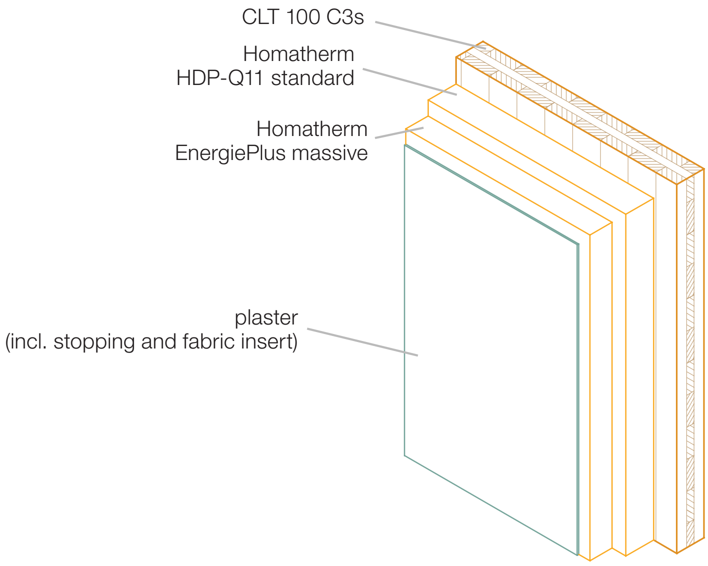
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Mineral wool	16, 18	0.035	1	18	A1
CLT 120 C3s	12	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
OSB	1.5	0.130	200-300	600	B
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 120	35	0.14	adequate	27.2	45	
18	REI 120	35	0.13	adequate	27.2	45	

1.13 External wall





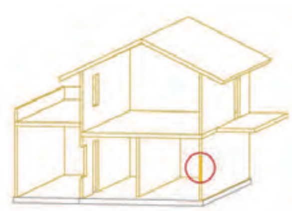
Component design

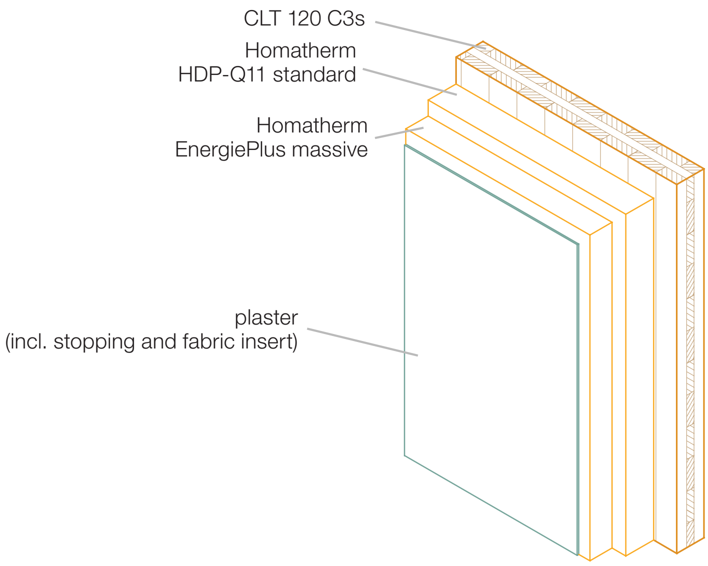
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Homatherm EnergiePlus massive	8, 6	0.039	3	140	E
Homatherm HDP-Q11 standard	12, 10	0.038	3	110	E
CLT 100 C3s	10	0.110	50	470	D

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.21	adequate	34.6	38	
20	REI 60	35	0.18	adequate	34.7	38	

1.14 External wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Homatherm EnergiePlus massive	8, 6	0.039	3	140	E
Homatherm HDP-Q11 standard	12, 10	0.038	3	110	E
CLT 120 C3s	12	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.20	adequate	33.3	38	
20	REI 60	35	0.17	adequate	33.3	38	

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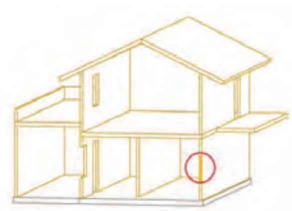
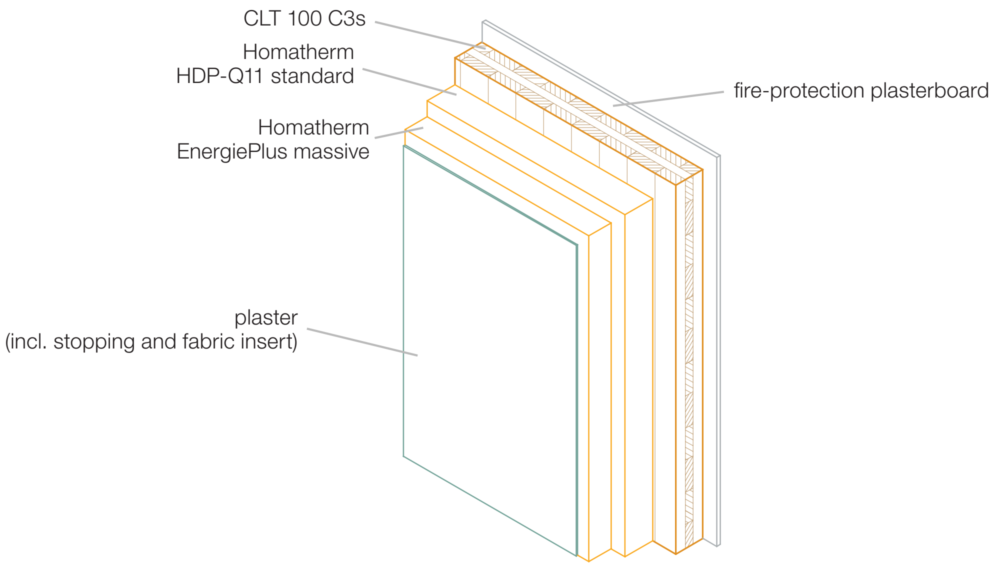
Building physics

1.15 External wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Homatherm EnergiePlus massive	8, 6	0.039	3	140	E
Homatherm HDP-Q11 standard	12, 10	0.038	3	110	E
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.21	adequate	38.7	39	
20	REI 90	35	0.17	adequate	38.7	39	

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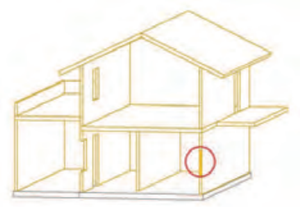
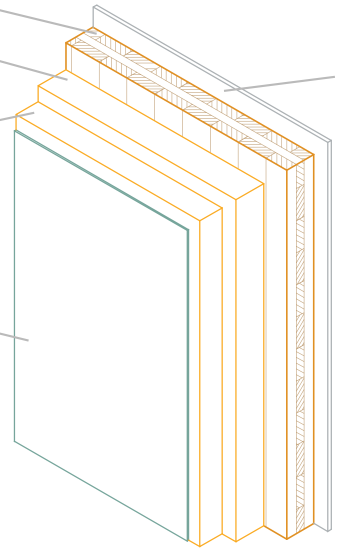
1.16 External wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Homatherm EnergiePlus massive	8, 6	0.039	3	140	E
Homatherm HDP-Q11 standard	12, 10	0.038	3	110	E
CLT 120 C3s	12	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.20	adequate	37.4	39	
20	REI 90	35	0.17	adequate	37.4	39	

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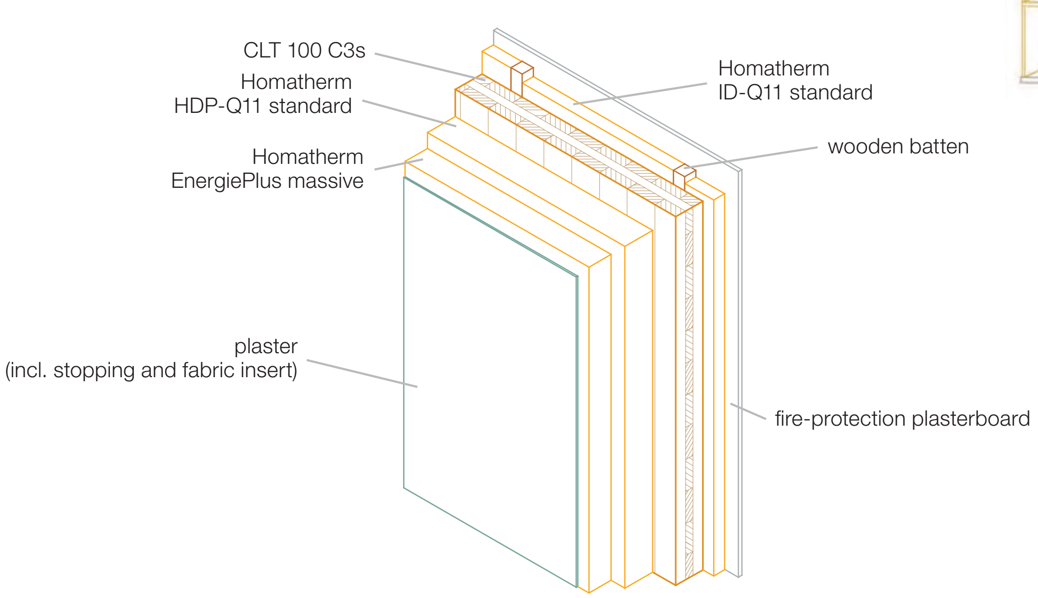
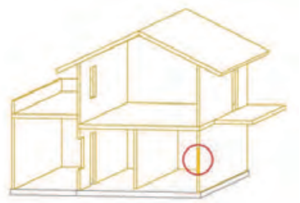
Building physics

1.17 External wall





Component design

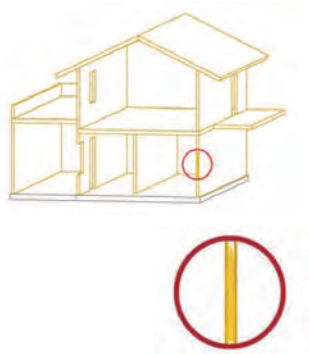
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Homatherm EnergiePlus massive	8, 6	0.039	3	140	E
Homatherm HDP-Q11 standard	12, 10	0.038	3	110	E
CLT 100 C3s	10	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 50/40, e = 62.5 cm	4	0.130	50	500	D
Homatherm ID-Q11 standard	4	0.038	3	110	E
Fire-protection plasterboard	1.5	0.250		800	A2

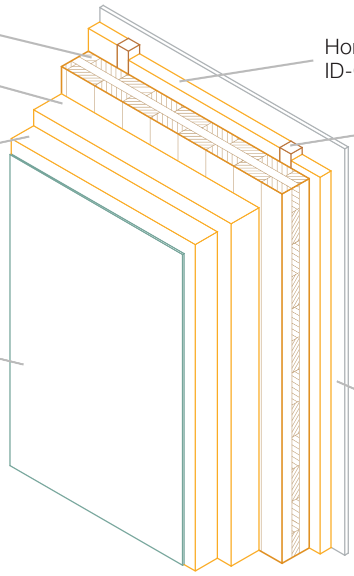
Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 120	35	0.18	adequate	18.1	44	
20	REI 120	35	0.15	adequate	18.1	44	

Building physics

1.18 External wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Homatherm EnergiePlus massive	8, 6	0.039	3	140	E
Homatherm HDP-Q11 standard	12, 10	0.038	3	110	E
CLT 120 C3s	12	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 50/40, e = 62.5 cm	4	0.130	50	500	D
Homatherm ID-Q11 standard	4	0.038	3	110	E
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 120	35	0.17	adequate	18.0	44	
20	REI 120	35	0.15	adequate	18.0	44	

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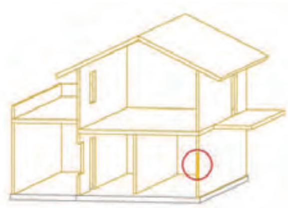
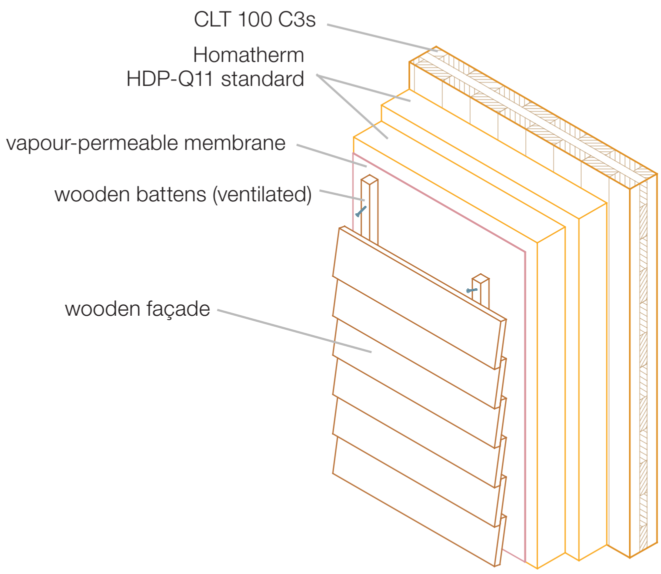
1.19 External wall





Component design

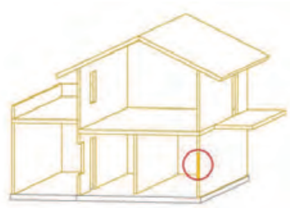
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
Homatherm HDP-Q11 standard, 2 layers	16, 20	0.038	3	110	E
CLT 100 C3s	10	0.110	50	470	D

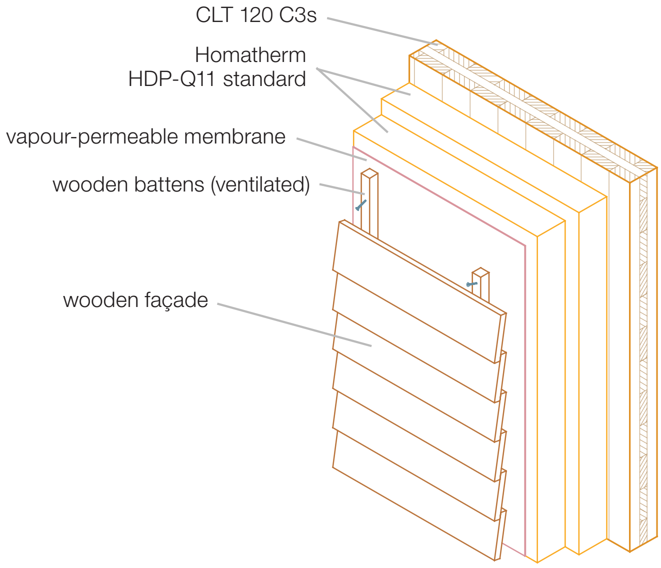
Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.21	adequate	34.7	43	
20	REI 60	35	0.17	adequate	34.8	43	

Building physics

1.20 External wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
Homatherm HDP-Q11 standard, 2 layers	16, 18, 20, 24	0.038	3	110	E
CLT 120 C3s	12	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.20	adequate	33.4	43	
18	REI 60	35	0.18	adequate	33.4	43	
20	REI 60	35	0.17	adequate	33.4	43	
24	REI 60	35	0.15	adequate	33.4	44	

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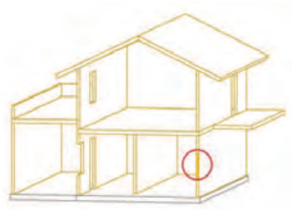
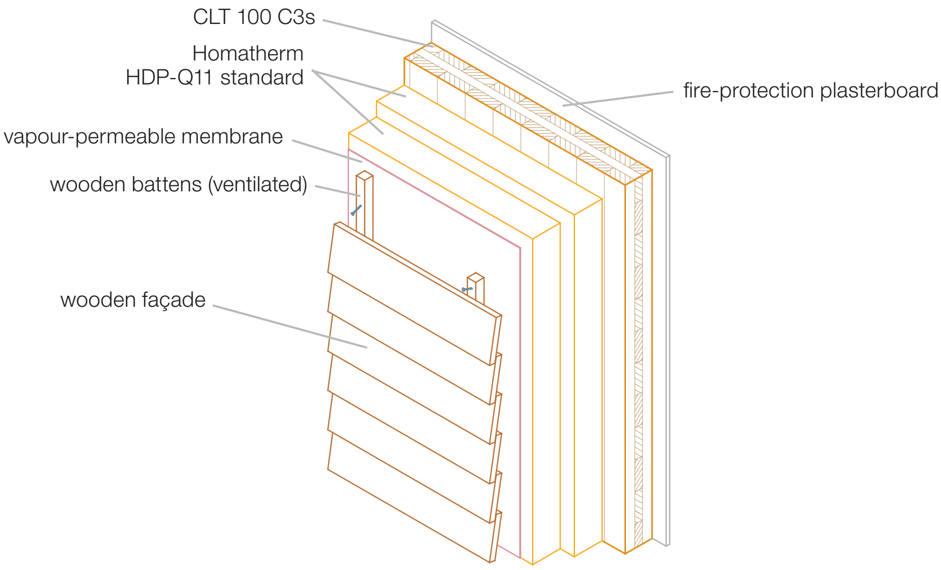
1.21 External wall





Component design

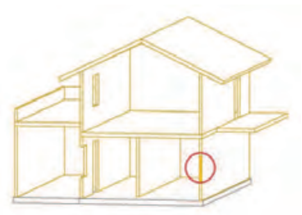
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
Homatherm HDP-Q11 standard, 2 layers	16, 20	0.038	3	110	E
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

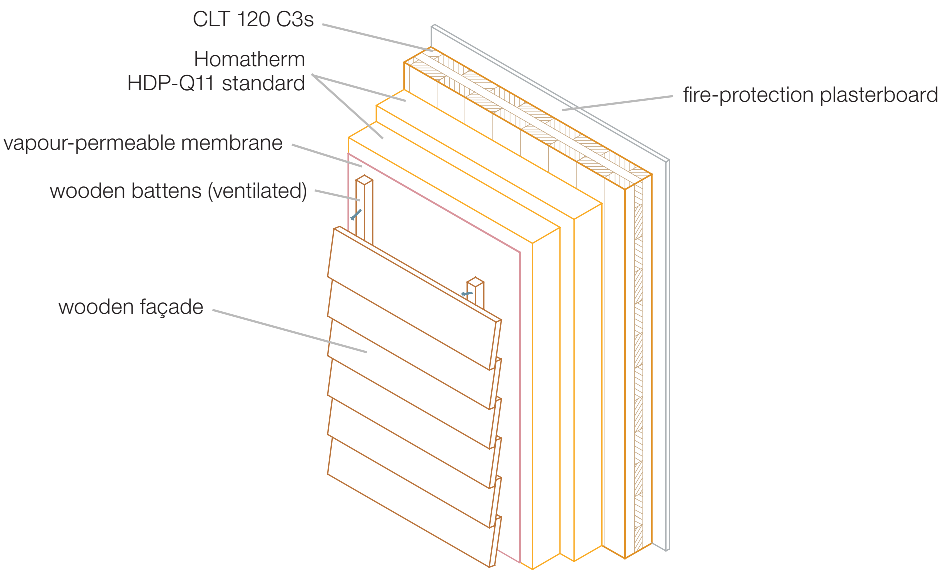
Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.20	adequate	38.7	44	
20	REI 90	35	0.17	adequate	38.8	44	

Building physics

1.22 External wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
Homatherm HDP-Q11 standard, 2 layers	16, 20	0.038	3	110	E
CLT 120 C3s	12	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.20	adequate	37.4	44	
20	REI 90	35	0.17	adequate	37.4	44	

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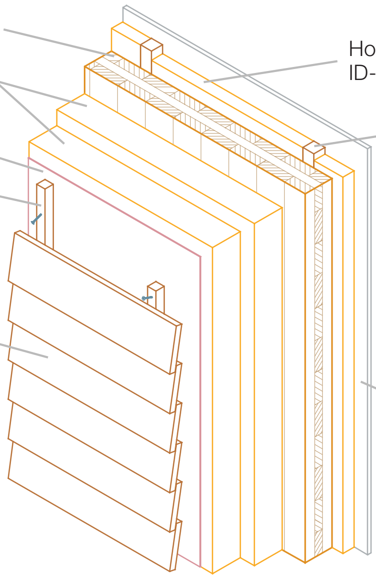
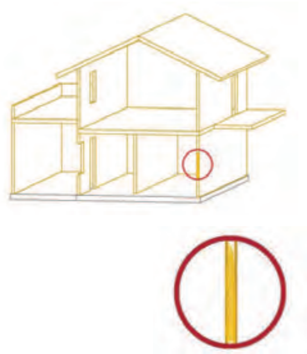
Building physics

1.23 External wall



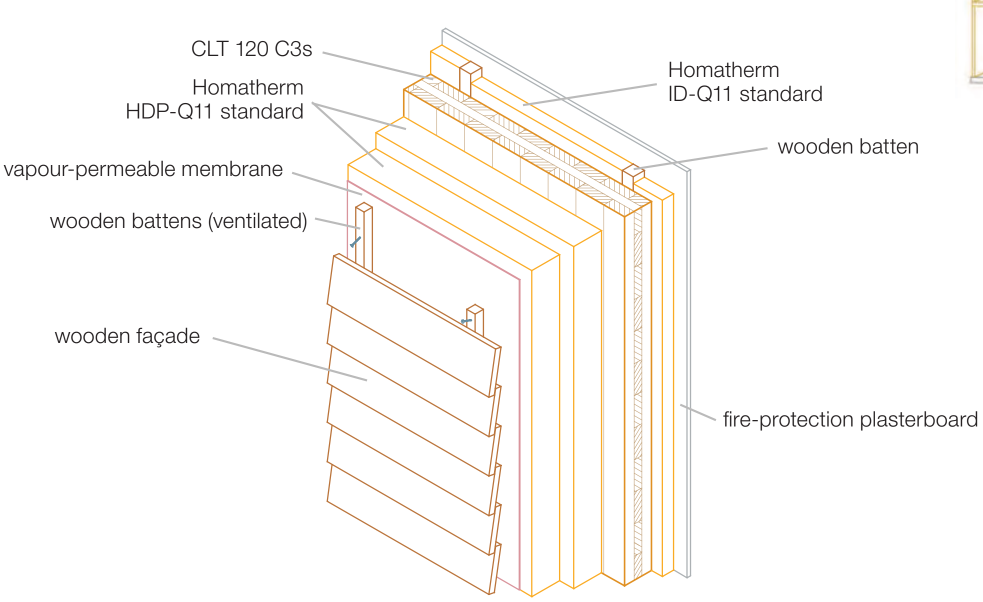


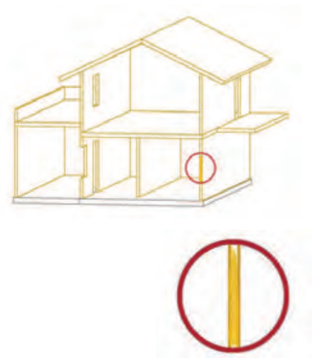
Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
Homatherm HDP-Q11 standard, 2 layers	16, 20	0.038	3	110	E
CLT 100 C3s	10	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 50/40, e = 62.5 cm	4	0.130	50	500	D
Homatherm ID-Q11 standard	4	0.038	3	130	E
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 120	35	0.18	adequate	18.1	48	
20	REI 120	35	0.15	adequate	18.1	48	

rethink.
storaenso

1.24 External wall





Component design

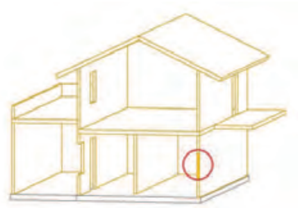
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
Homatherm HDP-Q11 standard, 2 layers	16, 20	0.038	3	130	E
CLT 120 C3s	12	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 50/40, e = 62.5 cm	4	0.130	50	500	D
Homatherm ID-Q11 standard	4	0.038	3	110	E
Fire-protection plasterboard	1.5	0.250		800	A2

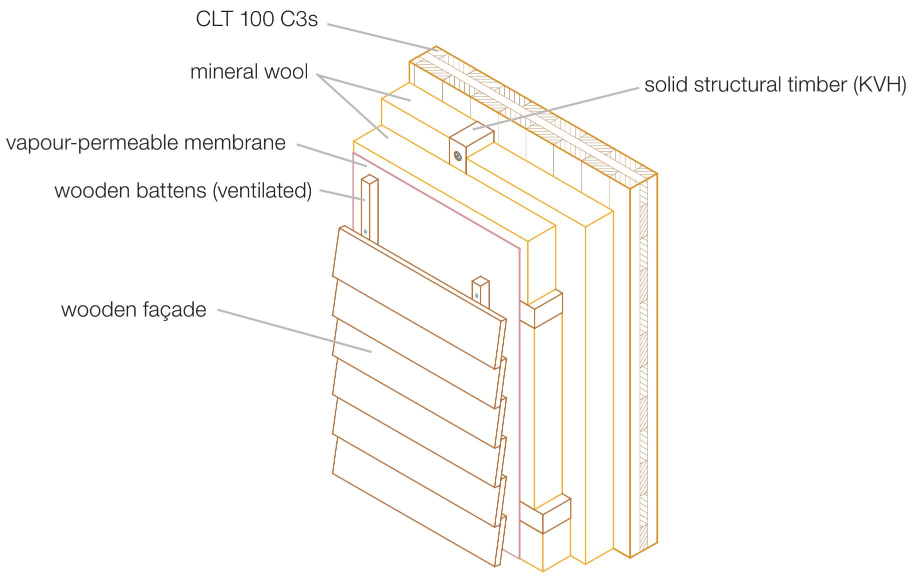
Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 120	35	0.17	adequate	16.5	48	
20	REI 120	35	0.15	adequate	16.5	48	

rethink.
storaenso

1.25 External wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
KVH structure, insulated:					
Structural timber 6/x, e = 62.5 cm	16, 20, 26	0.130	50	500	D
Mineral wool	16, 20, 26	0.035	1	18	A1
CLT 100 C3s	10	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.20	adequate	34.4	47	
20	REI 60	35	0.16	adequate	34.7	47	
26	REI 60	35	0.13	adequate	34.8	48	

rethink.

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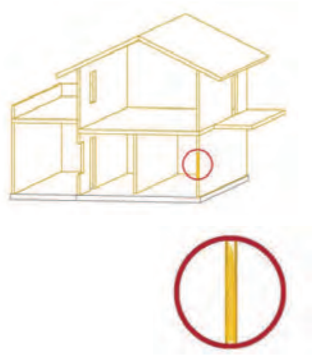
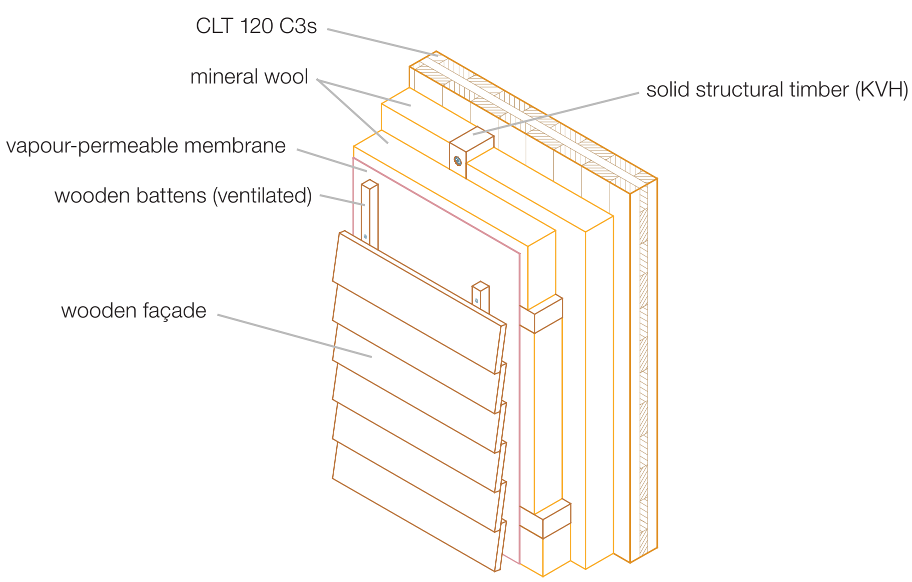
Building physics

1.26 External wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
KVH structure, insulated:					
Structural timber 6/x, e = 62.5 cm	16, 20, 26	0.130	50	500	D
Mineral wool	16, 20, 26	0.035	1	18	A1
CLT 120 C3s	12	0.110	50	470	D

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 60	35	0.19	adequate	33.3	47	
20	REI 60	35	0.16	adequate	33.4	47	
26	REI 60	35	0.13	adequate	33.4	48	

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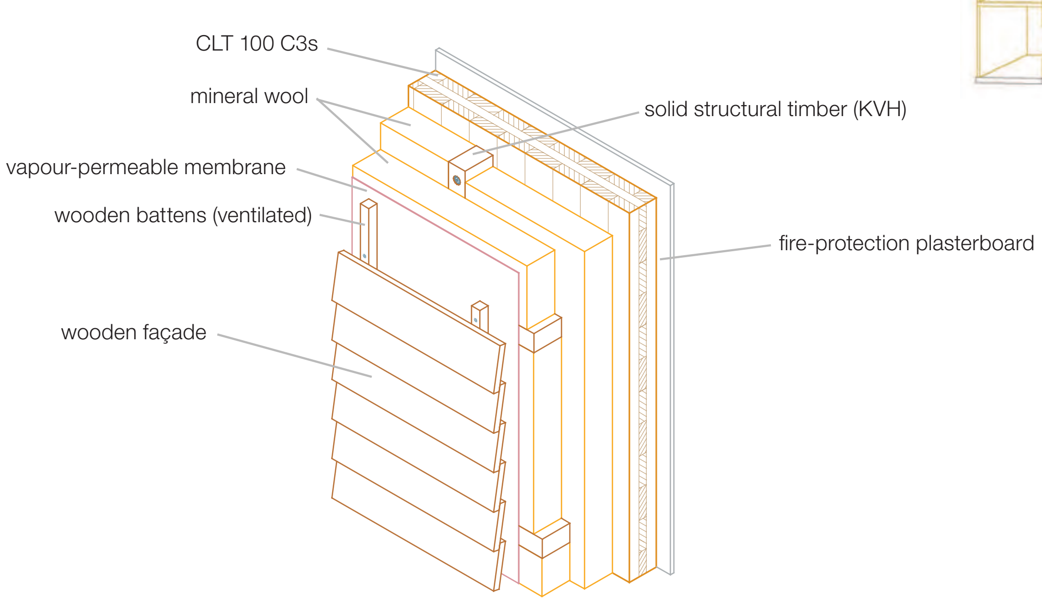
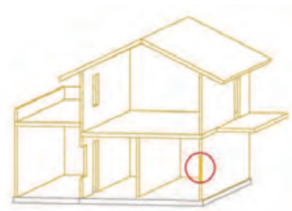
1.27 External wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
KVH structure, insulated:					
Structural timber 6/x, e = 62.5 cm	16, 20, 26	0.130	50	500	D
Mineral wool	16, 20, 26	0.035	1	18	A1
CLT 100 C3s	12	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.19	adequate	38.7	51	
20	REI 90	35	0.16	adequate	38.7	51	
26	REI 90	35	0.13	adequate	38.8	52	

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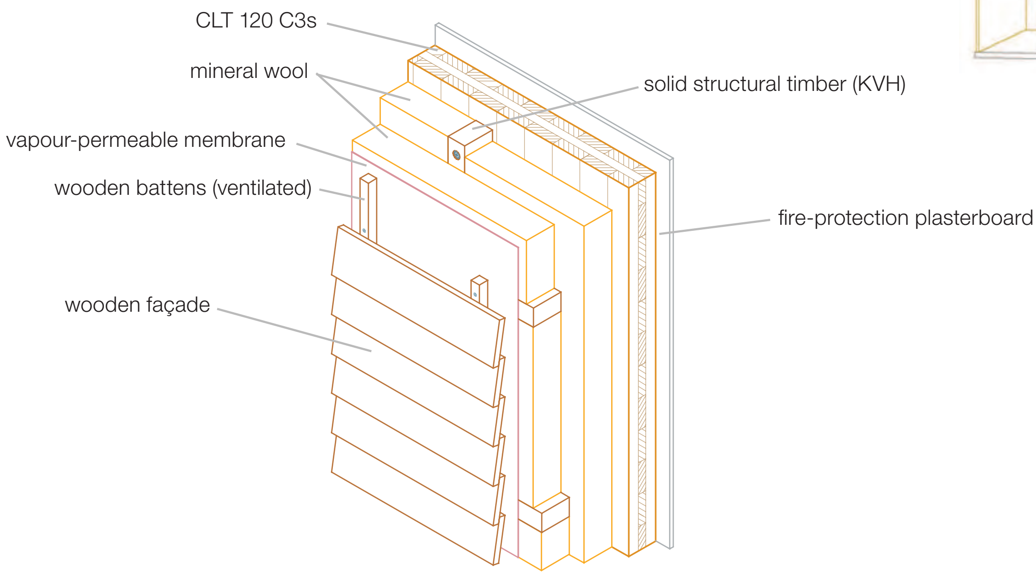
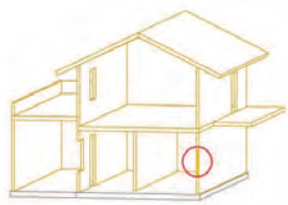
Building physics

1.28 External wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Wooden façade	2.5	0.130	50	500	D
Wooden battens (ventilated)	3	0.130	50	500	D
Vapour-permeable membrane					
KVH structure, insulated:					
Structural timber 6/x, e = 62.5 cm	16, 20, 26	0.130	50	500	D
Mineral wool	16, 20, 26	0.035	1	18	A1
CLT 120 C3s	12	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
16	REI 90	35	0.19	adequate	37.4	51	
20	REI 90	35	0.16	adequate	37.3	51	
26	REI 90	35	0.13	adequate	37.4	52	

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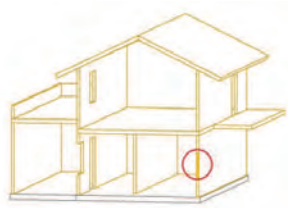
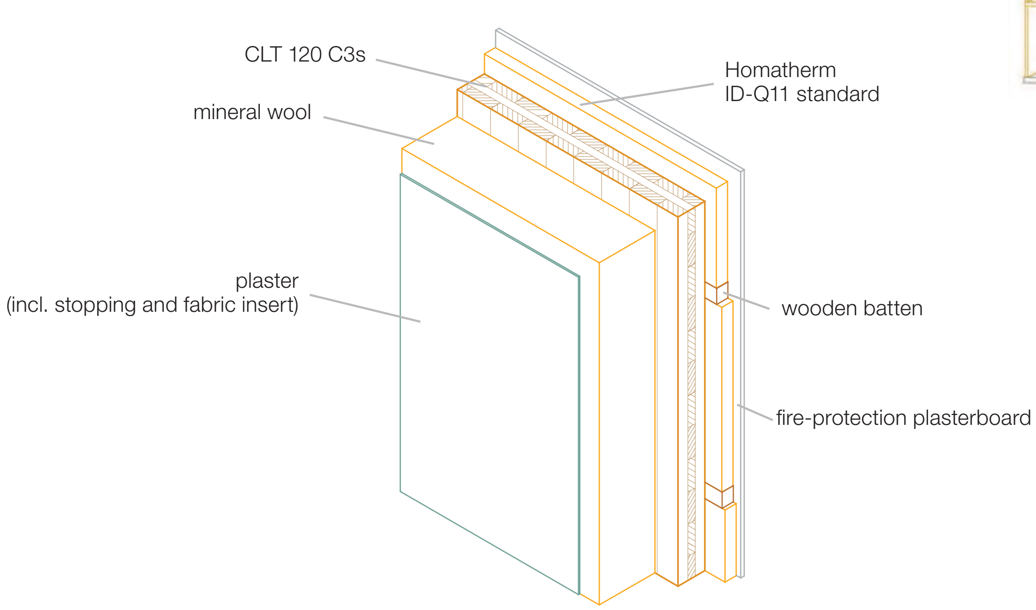
Building physics

1.29 External wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Plaster (incl. stopping and fabric insert)	0.5	1.000	10-35	2,000	A1
Mineral wool	18	0.035	1	18	A1
CLT 120 C3s	12	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 50/40, e = 62.5 cm	4	0.130	50	500	D
Homatherm ID-Q11 standard	4	0.038	3	130	E
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
18	REI 120	35	0.14	adequate	16.3	44	

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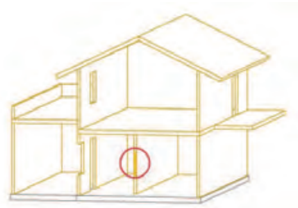
Internal walls

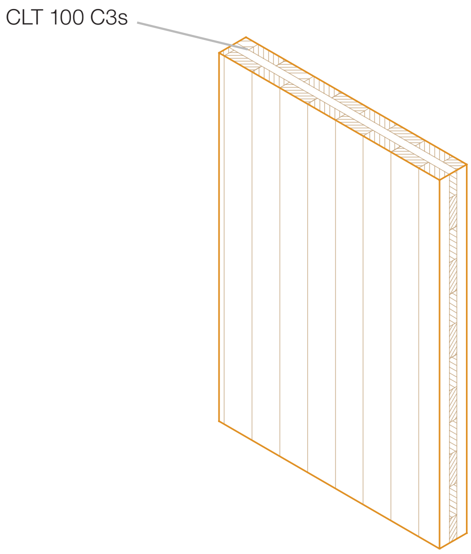
Building physics

Component	Left structure	CLT	Right structure
2.1	CLT visible quality	CLT 100 C3s	CLT visible quality
2.2	CLT visible quality	CLT 120 C3s	CLT visible quality
2.3	CLT visible quality	CLT 100 C3s	Panelled with GKF plasterboard
2.4	CLT visible quality	CLT 120 C3s	Panelled with GKF plasterboard
2.5	CLT visible quality	CLT 100 C3s	Facing with GKF plasterboard
2.6	CLT visible quality	CLT 120 C3s	Facing with GKF plasterboard
2.7	Panelled with GKF plasterboard	CLT 100 C3s	Panelled GKF plasterboard
2.8	Panelled with GKF plasterboard	CLT 120 C3s	Panelled with GKF plasterboard
2.9	Panelled with GKF plasterboard	CLT 100 C3s	Facing with GKF plasterboard
2.10	Facing with GKF plasterboard	CLT 100 C3s	Facing with GKF plasterboard
2.11	Facing with GKF plasterboard	CLT 120 C3s	Facing with GKF plasterboard

Building physics

2.1 Internal wall



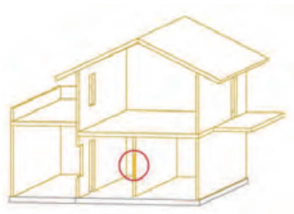


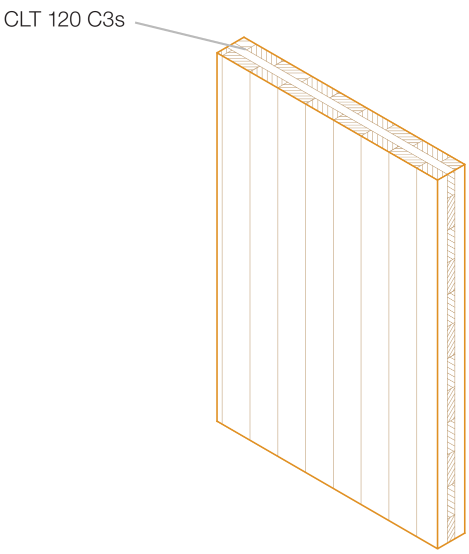
Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
CLT 100 C3s	10	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 60	35	0.855	adequate	29.6	34	

Building physics

2.2 Internal wall





Component design

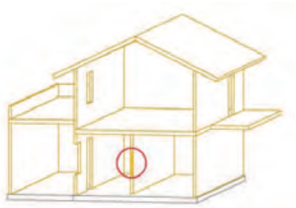
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
CLT 120 C3s	12	0.110	50	470	D

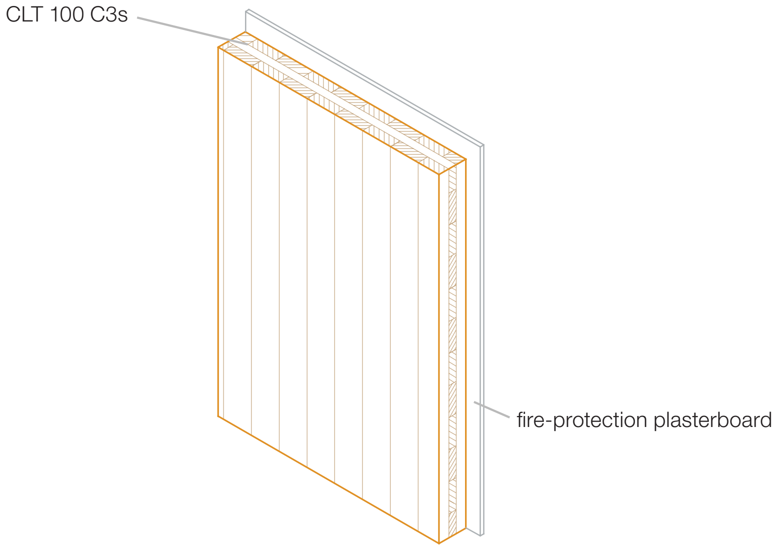
Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 60	35	0.740	adequate	31.1	35	

Building physics

2.3 Internal wall

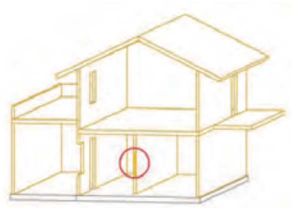


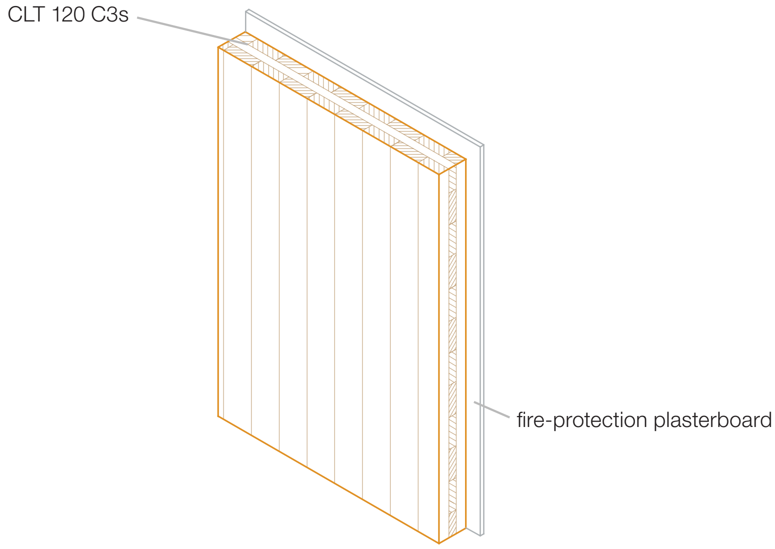


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 90	35	0.820	adequate	FPP 34.5	36	
					Wood 30.0		

2.4 Internal wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
CLT 120 C3s	12	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 90	35	0.714	adequate	FPP 36.0 Wood 31.4	37	

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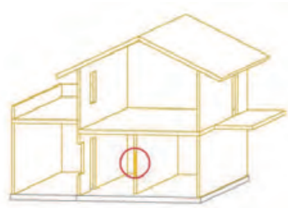
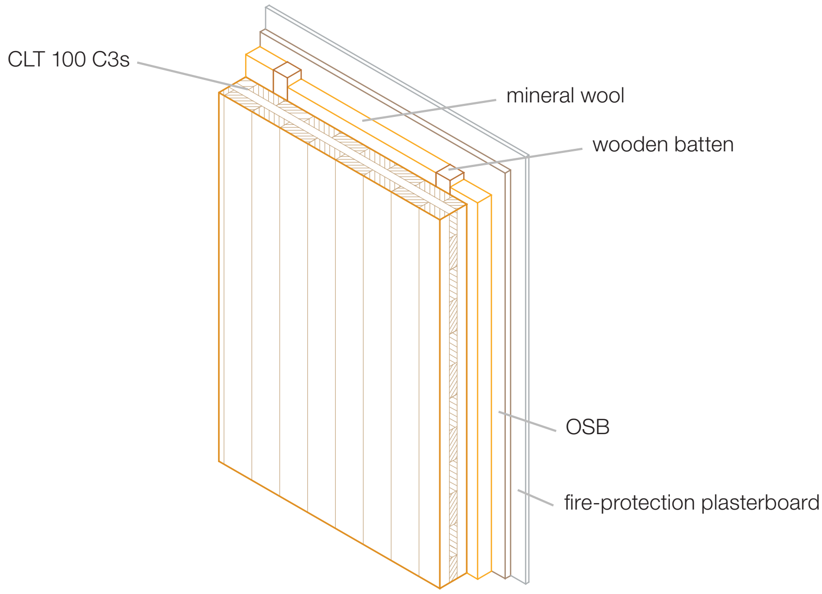
2.5 Internal wall

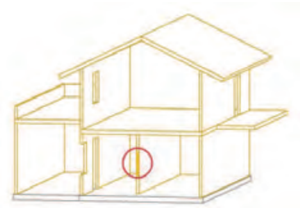


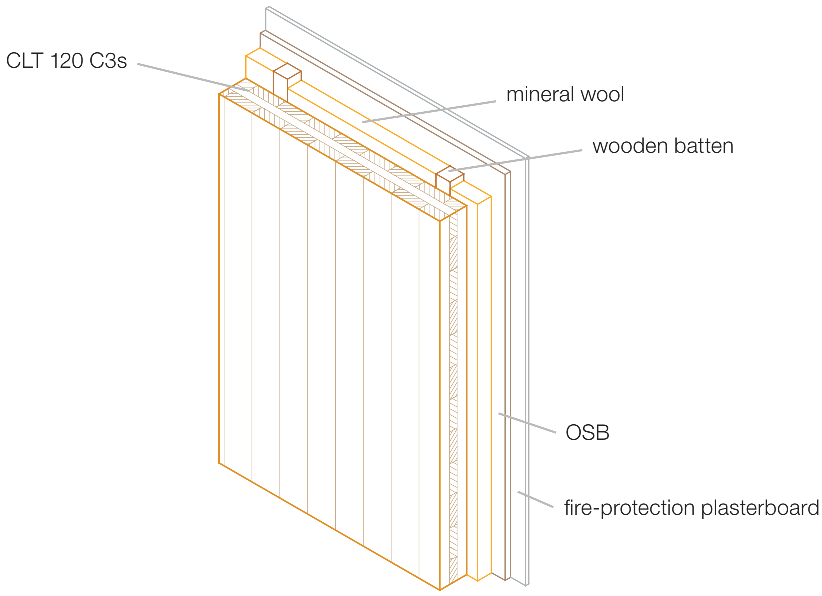


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
CLT 100 C3s	10	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
OSB	1.5	0.130	200-300	600	B
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 120	35	0.382	adequate	+ Service cavity 27.2	41	
					Wood 33.8		

2.6 Internal wall





Component design

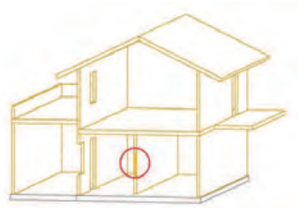
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
CLT 120 C3s	12	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
OSB	1.5	0.130	200-300	600	B
Fire-protection plasterboard	1.3	0.250		800	A2

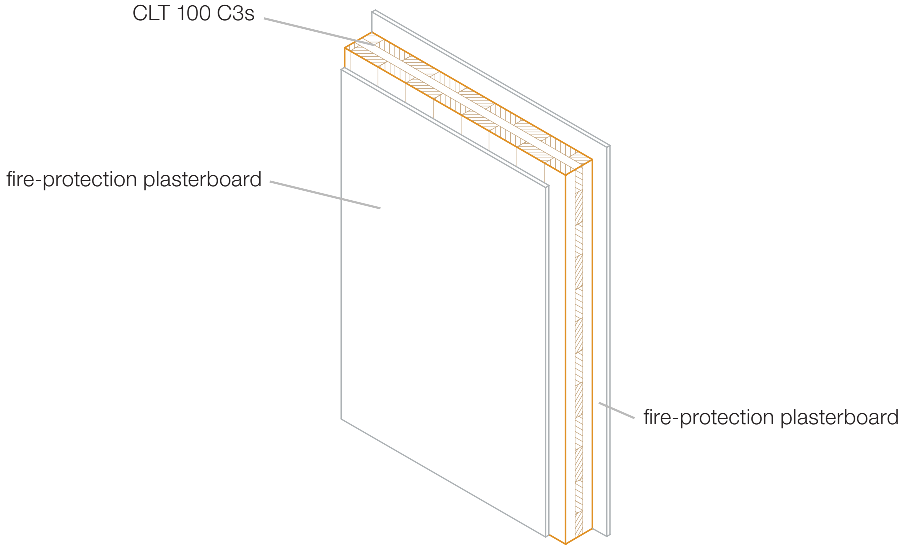
Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 120	35	0.357	adequate	Service cavity 27.2 Wood 33.0	41	

Building physics

2.7 Internal wall

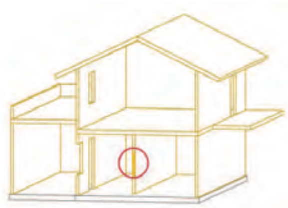


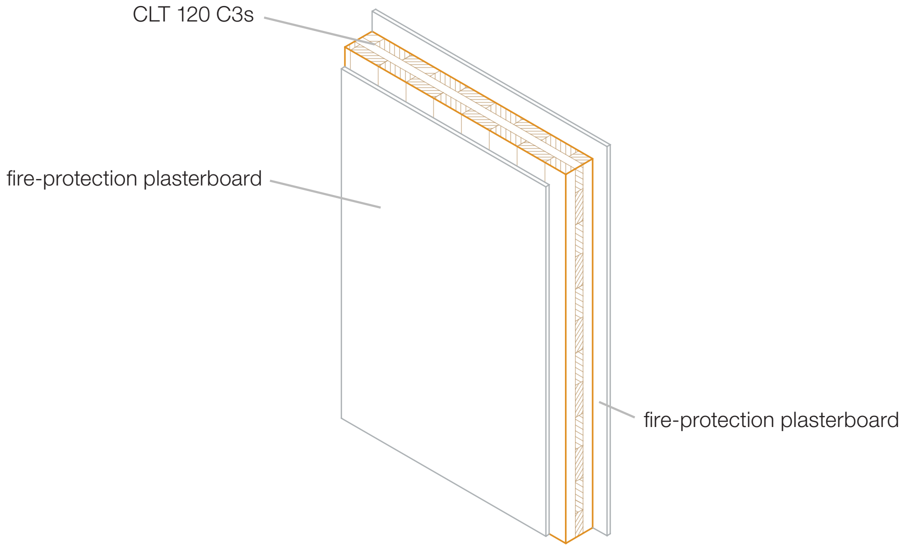


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 90	35	0.788	adequate	35.0	38	

2.8 Internal wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
CLT 120 C3s	12	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 90	35	0.689	adequate	36.2	38	

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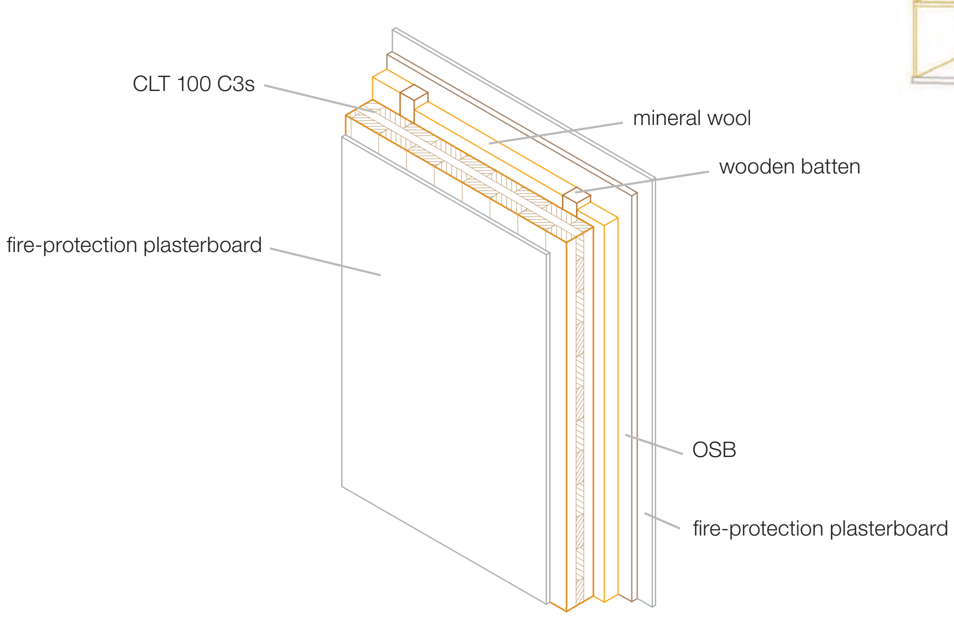
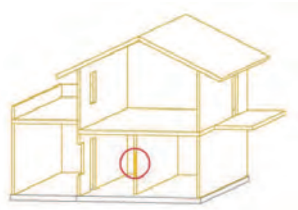
Building physics

2.9 Internal wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
CLT 100 C3s	10	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
OSB	1.5	0.130	200-300	600	B
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

<table>
<tr><th>Insul. thick.</th><th colspan="2">Fire protection i → o</th><th colspan="3">Thermal performance</th><th colspan="2">Acoustic performance</th></tr>
<tr><th>[cm]</th><th>Fire resistance</th><th>Load [kN/m]</th><th>U-value [W/m²K]</th><th>Permeability</th><th>Thermal mass $m_{w,B,A}$ [kg/m²]</th><th>R_w</th><th>$L_{n,w}$</th></tr>
<tr><td rowspan="2">–</td><td rowspan="2">REI 120</td><td rowspan="2">35</td><td rowspan="2">0.375</td><td rowspan="2">adequate</td><td>Service cavity 27.1</td><td rowspan="2">42</td><td rowspan="2"></td></tr>
<tr><td>Wood 38.1</td></tr>
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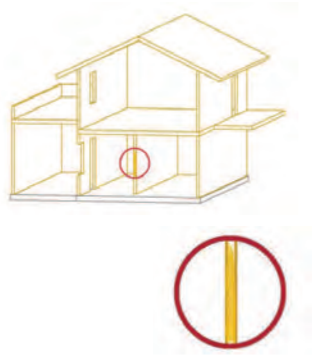
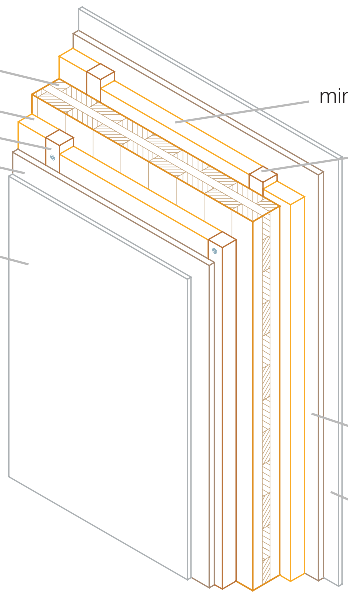
2.10 Internal wall



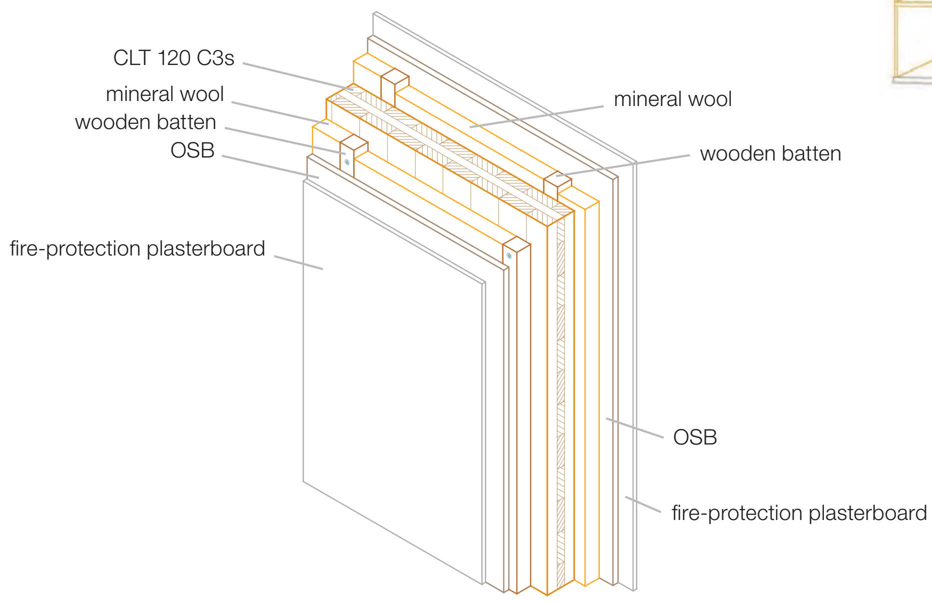


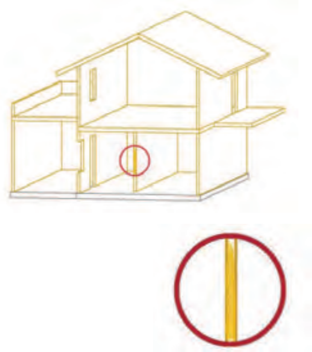
Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
OSB	1.5	0.130	200-300	600	B
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
CLT 100 C3s	10	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
OSB	1.5	0.130	200-300	600	B
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 120	35	0.247	adequate	27.2	46	

Building physics

2.11 Internal wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
OSB	1.5	0.130	200-300	600	B
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
CLT 120 C3s	12	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
OSB	1.5	0.130	200-300	600	B
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
–	REI 120	35	0.236	adequate	27.2	46	

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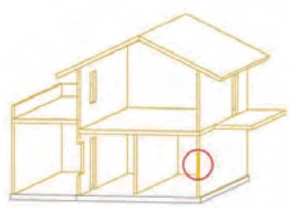
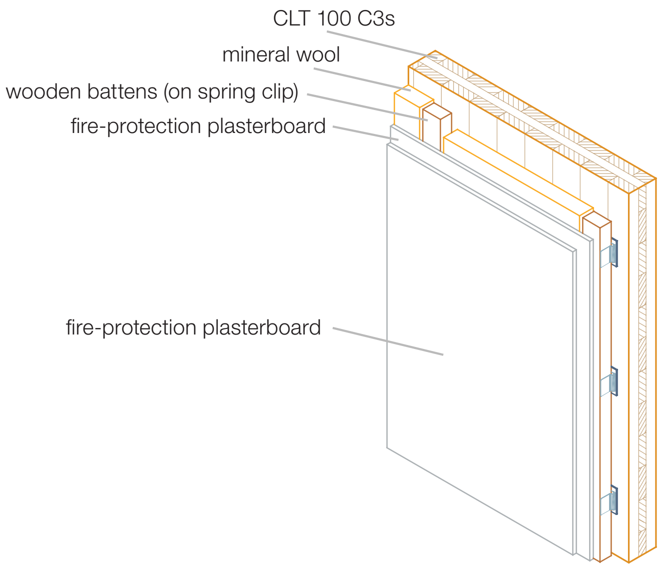
Partition walls

Building physics

Component	Left structure	CLT	Right structure
3.1	Facing with pivoting bracket	CLT 100 C3s	CLT visible quality
3.2	Facing with pivoting bracket	CLT 120 C3s	CLT visible quality
3.3	Facing with pivoting bracket	CLT 100 C3s	Panelled with GKF plasterboard
3.4	Facing with pivoting bracket	CLT 120 C3s	Panelled with GKF plasterboard
3.5	Facing with pivoting bracket	CLT 100 C3s	Facing with pivoting bracket
3.6	Facing with pivoting bracket	CLT 120 C3s	Facing with pivoting bracket
3.7	CLT visible quality	2 x CLT 100 C3s	CLT visible quality
3.8	CLT visible quality	2 x CLT 100 C3s	Panelled with GKF plasterboard
3.9	CLT visible quality	2 x CLT 100 C3s	Facing with pivoting bracket
3.10	Panelled with GKF plasterboard	2 x CLT 100 C3s	Panelled with GKF plasterboard
3.11	Panelled with GKF plasterboard	2 x CLT 80 C3s	Panelled with GKF plasterboard
3.12	Panelled with GKF plasterboard	2 x CLT 100 C3s	Facing with pivoting bracket
3.13	Panelled with GKF plasterboard	2 x CLT 80 C3s	Facing with pivoting bracket
3.14	Panelled with GKF plasterboard	2 x CLT 100 C3s	Panelled with GKF plasterboard
3.15	Panelled with GKF plasterboard	2 x CLT 80 C3s	Panelled with GKF plasterboard
3.16	Facing with pivoting bracket	2 x CLT 100 C3s	Facing with pivoting bracket
3.17	Facing with pivoting bracket	2 x CLT 80 C3s	Facing with pivoting bracket

3.1 Partition wall





Component design

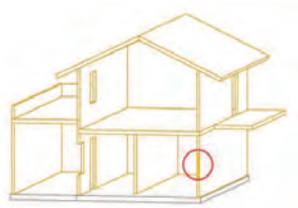
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	2.5	0.250		800	A2
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035		18	A1
CLT 100 C3s	10	0.110	50	470	D

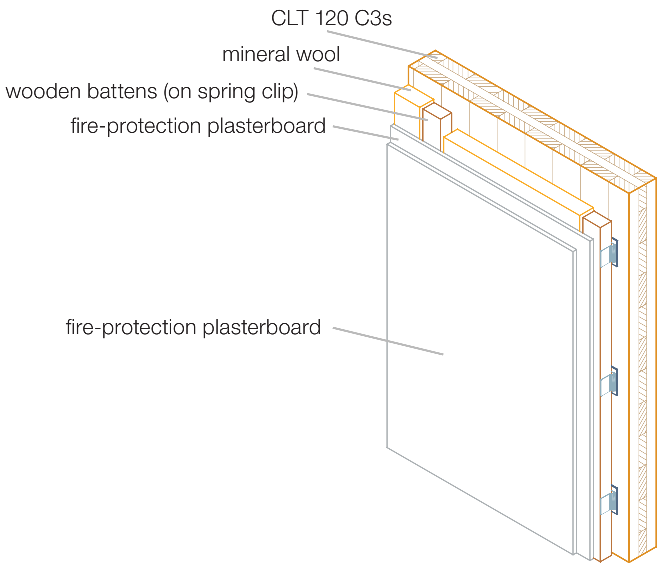
Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
7	REI 60	35	0.34	adequate	34.0	45	
	EI 120						

Building physics

3.2 Partition wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	2.5	0.250		800	A2
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035		18	A1
CLT 120 C3s	12	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
7	REI 60	35	0.32	adequate	33.1	45	
	EI 120						

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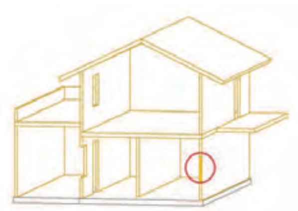
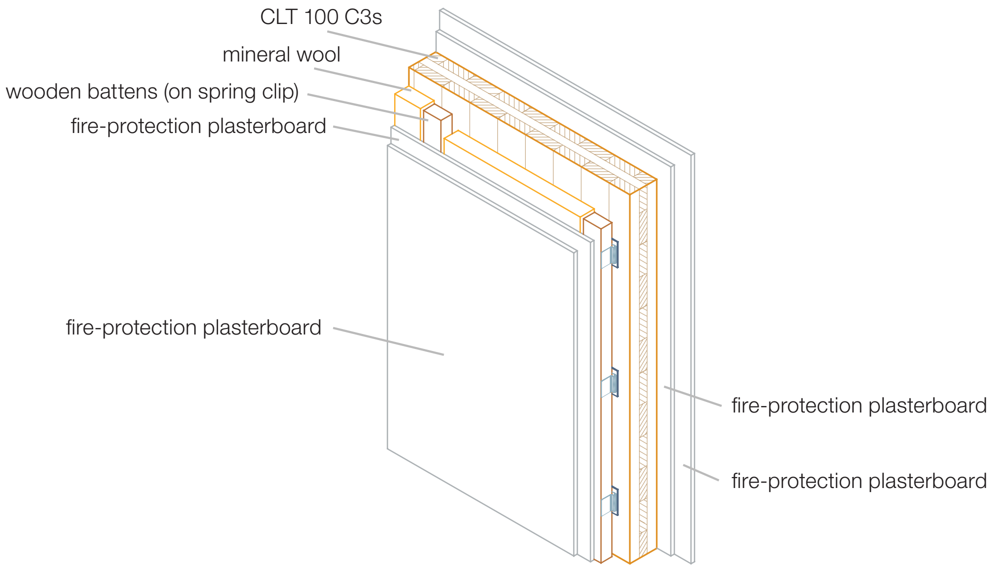
3.3 Partition wall



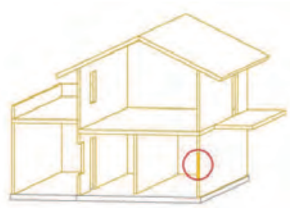


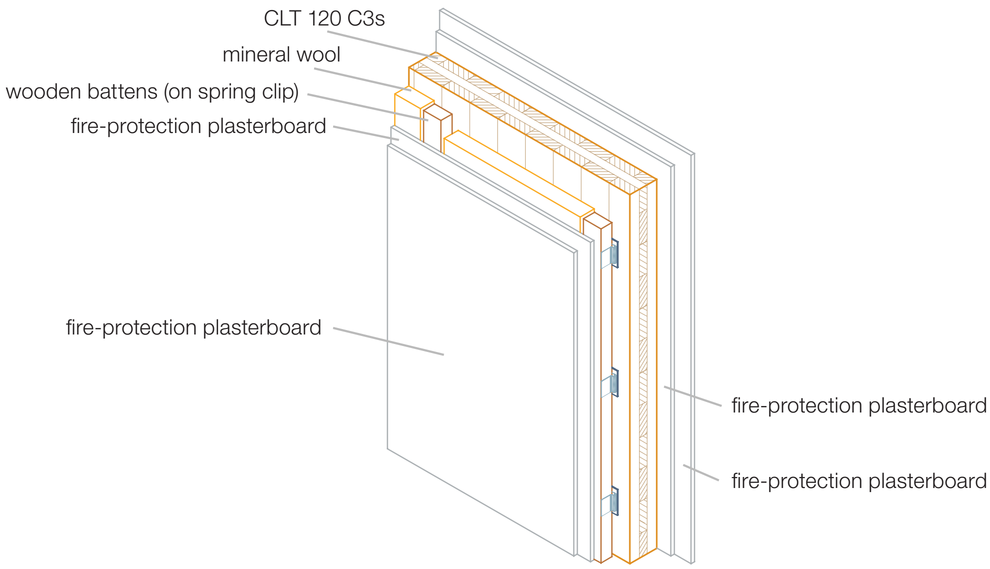
Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	2.5	0.250		800	A2
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035		18	A1
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	2.5	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
7	REI 90 / EI 120	35	0.33	adequate	42.2	46	

Building physics

3.4 Partition wall





Component design

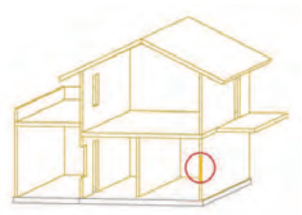
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	2.5	0.250		800	A2
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035		18	A1
CLT 120 C3s	12	0.110	50	470	D
Fire-protection plasterboard	2.5	0.250		800	A2

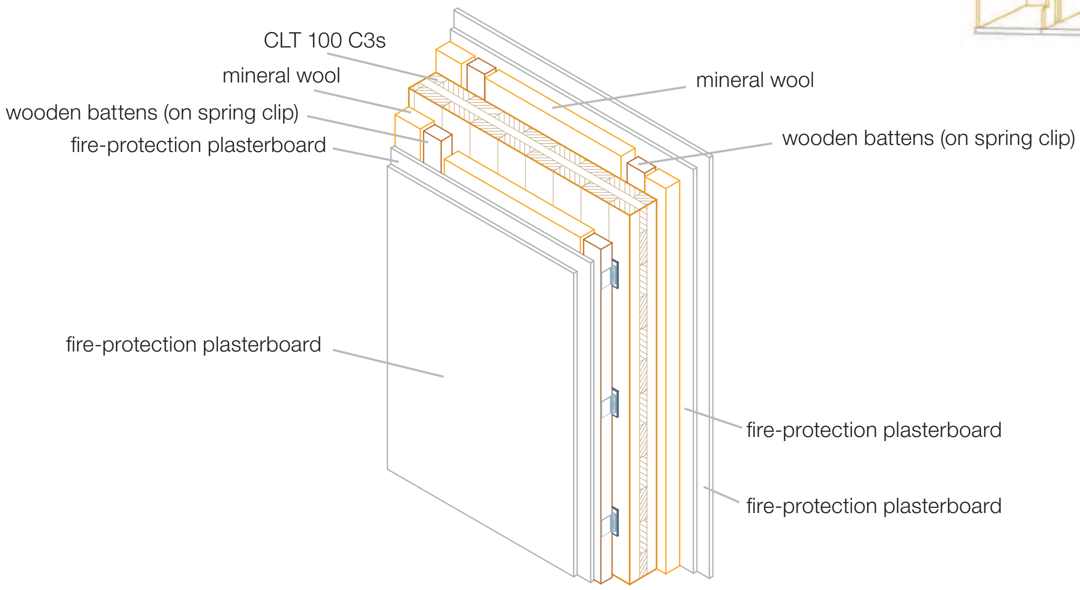
Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
7	REI 90 / EI 120	35	0.31	adequate	41.4	46	

Building physics

3.5 Partition wall





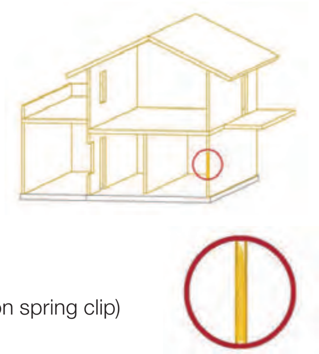
Component design

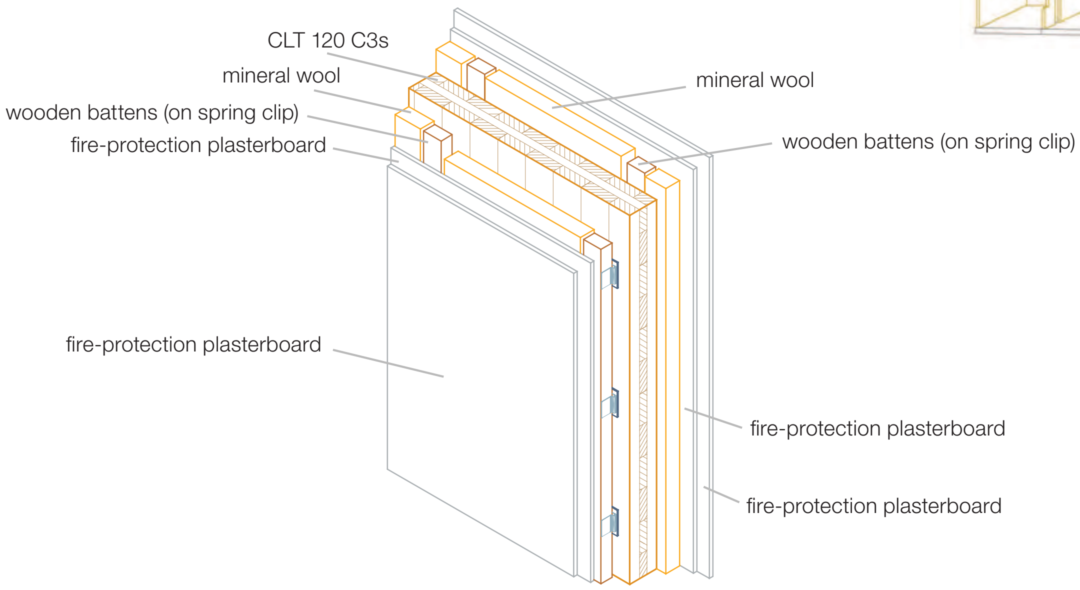
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	2.5	0.250		800	A2
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035		18	A1
CLT 100 C3s	10	0.110	50	470	D
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035		18	A1
Fire-protection plasterboard	2.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
2 x 7	REI 120	35	0.21	adequate	22.8	58	

3.6 Partition wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	2.5	0.250		800	A2
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035		18	A1
CLT 120 C3s	12	0.110	50	470	D
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035		18	A1
Fire-protection plasterboard	2.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
2 x 7	REI 120	35	0.20	adequate	22.8	58	

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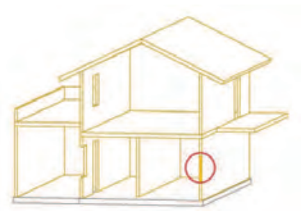
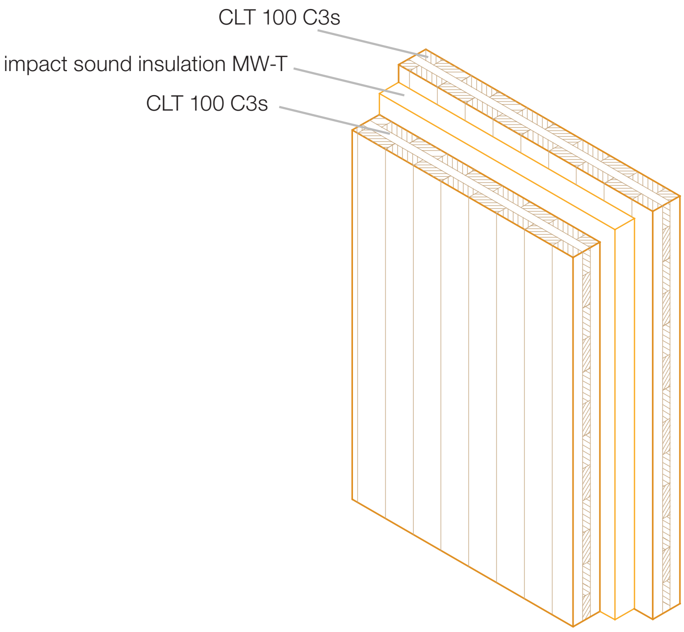
Building physics

3.7 Partition wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
CLT 100 C3s	10	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
CLT 100 C3s	10	0.110	50	470	D

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
6	REI 60	35	0.26	adequate	34.2	52	
	EI 120						

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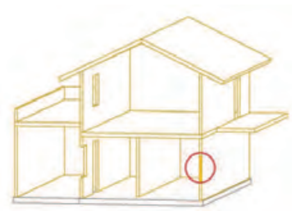
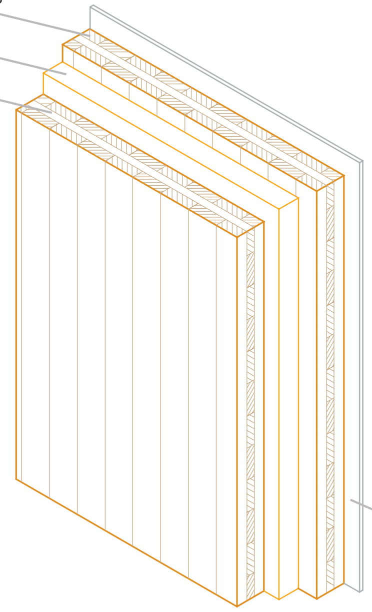
3.8 Partition wall





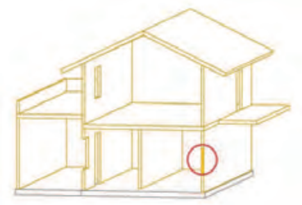
Component design

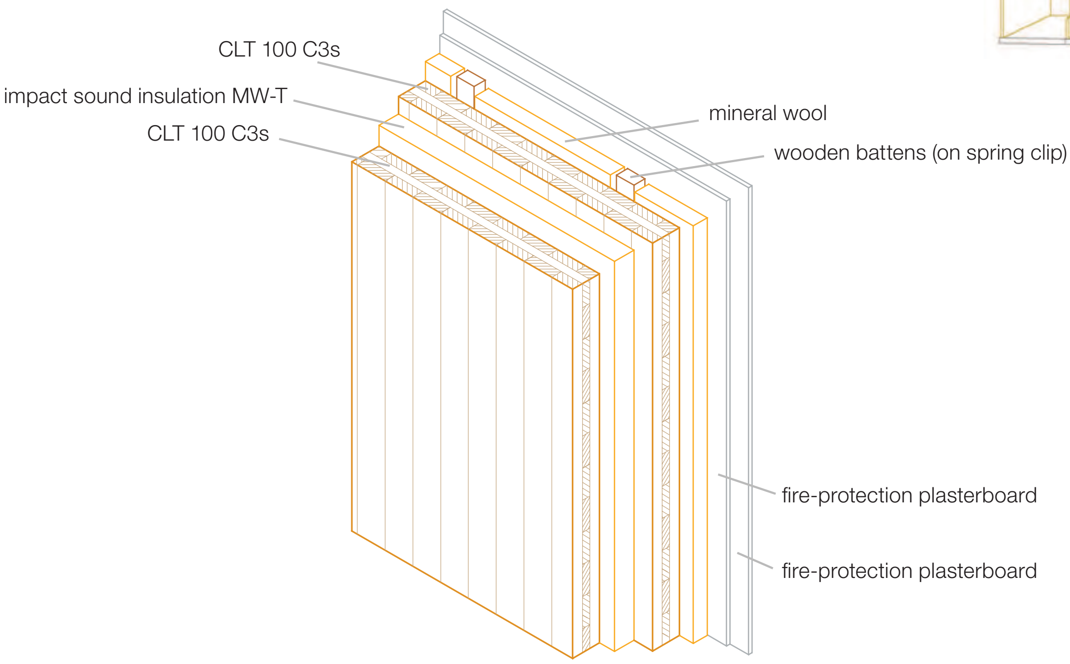
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
CLT 100 C3s	10	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
6	REI 90 EI 120	35	0.26	adequate	38.4	54	

3.9 Partition wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
CLT 100 C3s	10	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
CLT 100 C3s	10	0.110	50	470	D
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035	1	18	A1
Fire-protection plasterboard	2.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
7 + 6	REI 120	35	0.19	adequate	23.1	66	

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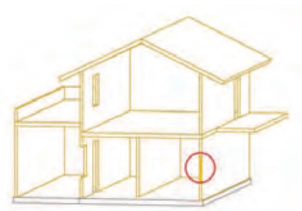
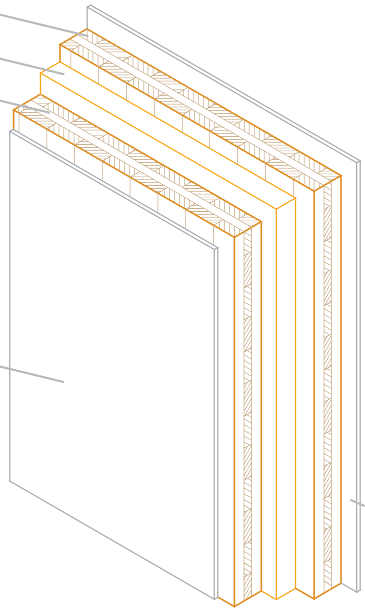
3.10 Partition wall

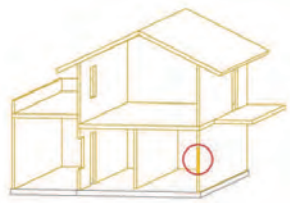


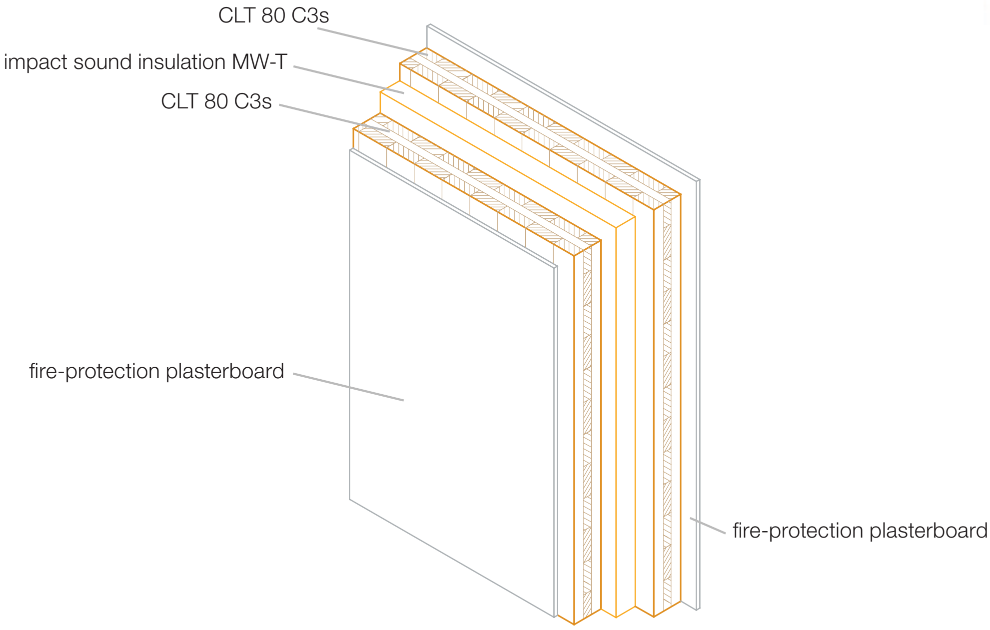


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
CLT 100 C3s	10	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
6	REI 90 EI 120	35	0.26	adequate	38.4	60	

3.11 Partition wall

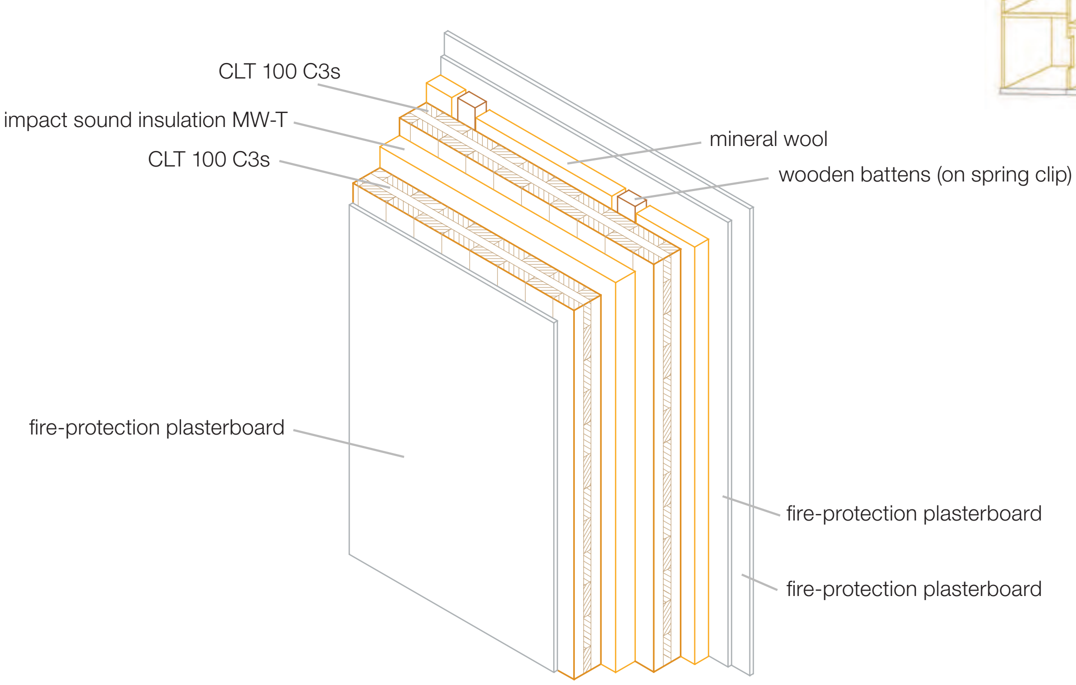


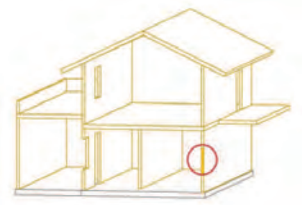


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
CLT 80 C3s	8	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
CLT 80 C3s	8	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
6	REI 90	35	0.26	adequate	38.4	60	
	EI 120						

3.12 Partition wall





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
CLT 100 C3s	10	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
CLT 100 C3s	10	0.110	50	470	D
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035	1	18	A1
Fire-protection plasterboard	2.5	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
7 + 6	REI 120	35	0.18	adequate	23.1	67	

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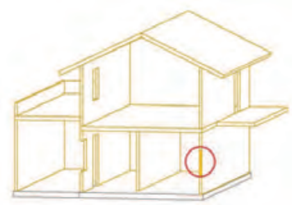
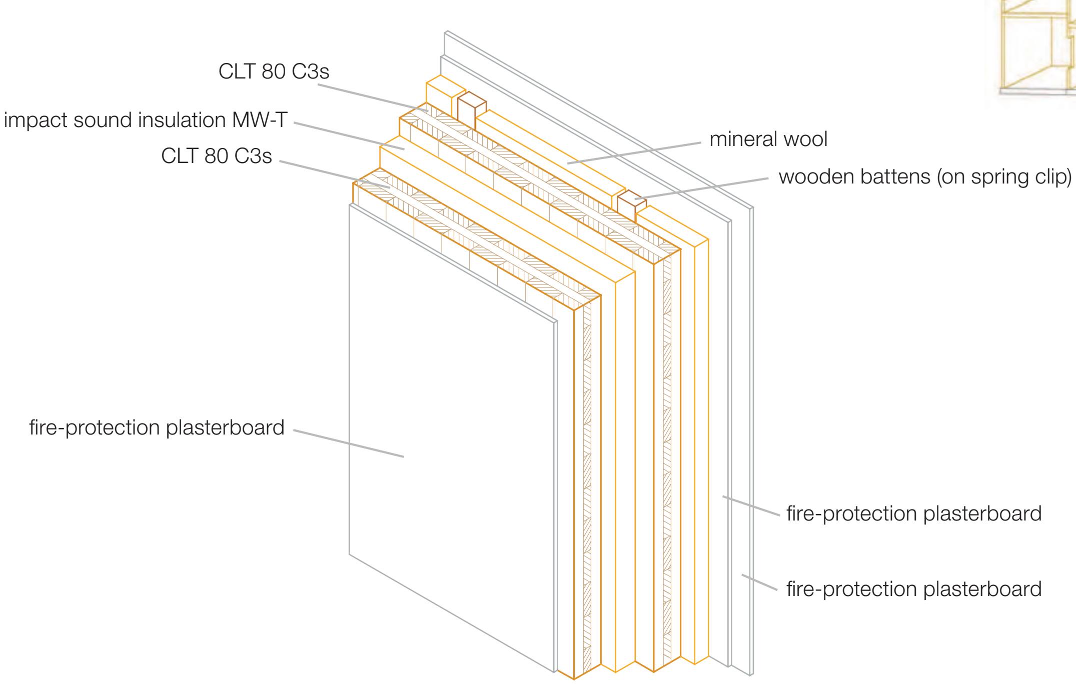
3.13 Partition wall



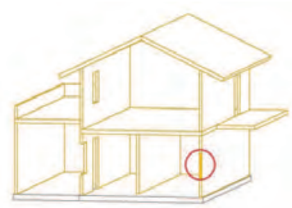
Component design

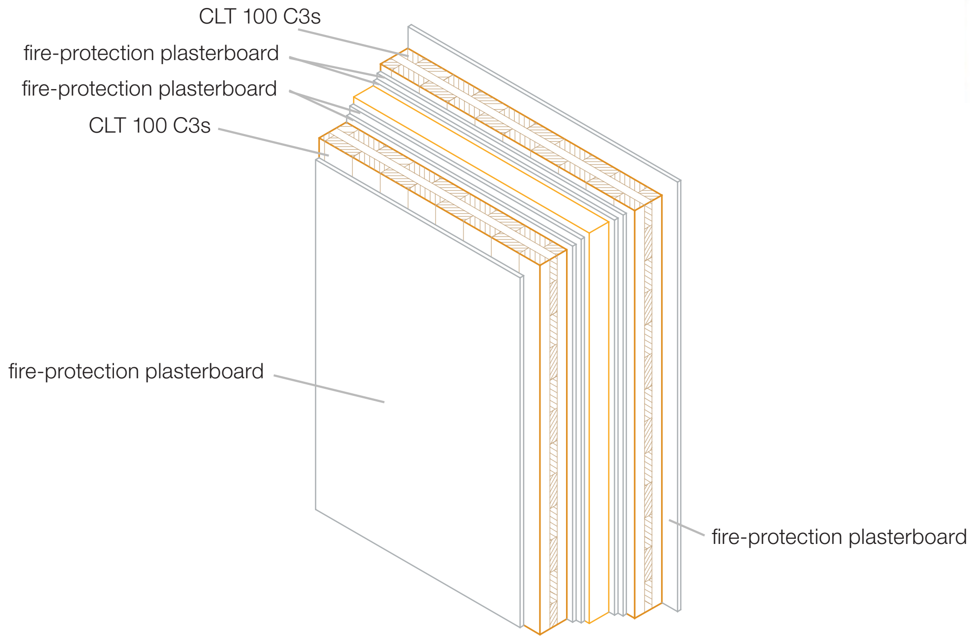
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
CLT 80 C3s	8	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
CLT 80 C3s	8	0.110	50	470	D
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035	1	18	A1
Fire-protection plasterboard	2.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
7 + 6	REI 90	35	0.20	adequate	14.9	66	
	EI 120						

3.14 Partition wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.5	0.250		800	A2
Fire-protection plasterboard	1.5	0.250		800	A2
Impact sound insulation MW-T	6	0.035	1	68	A1
Fire-protection plasterboard	1.5	0.250		800	A2
Fire-protection plasterboard	1.5	0.250		800	A2
CLT 100 C3s	10	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
6	REI 90 EI 120	35	0.24	adequate	36.8	70	

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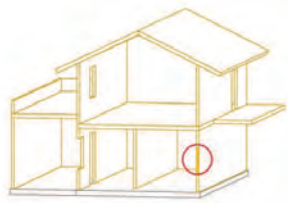
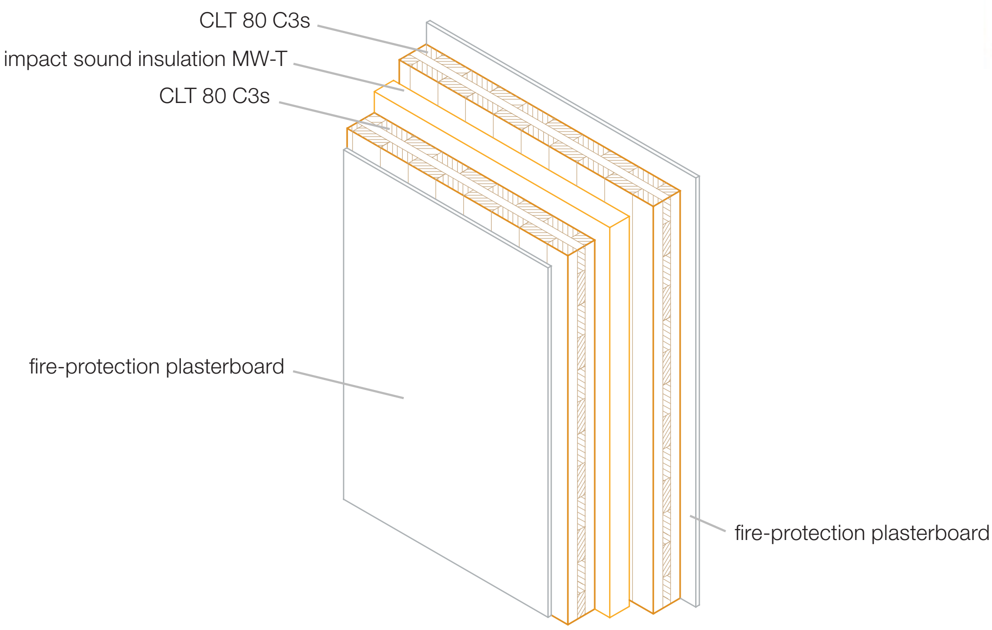
3.15 Partition wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	1.3	0.250		800	A2
CLT 80 C3s	8	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
Air gap	2				
CLT 80 C3s	8	0.110	50	470	D
Fire-protection plasterboard	1.3	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
6	REI 90 EI 120	35	0.27	adequate	39.4	60	

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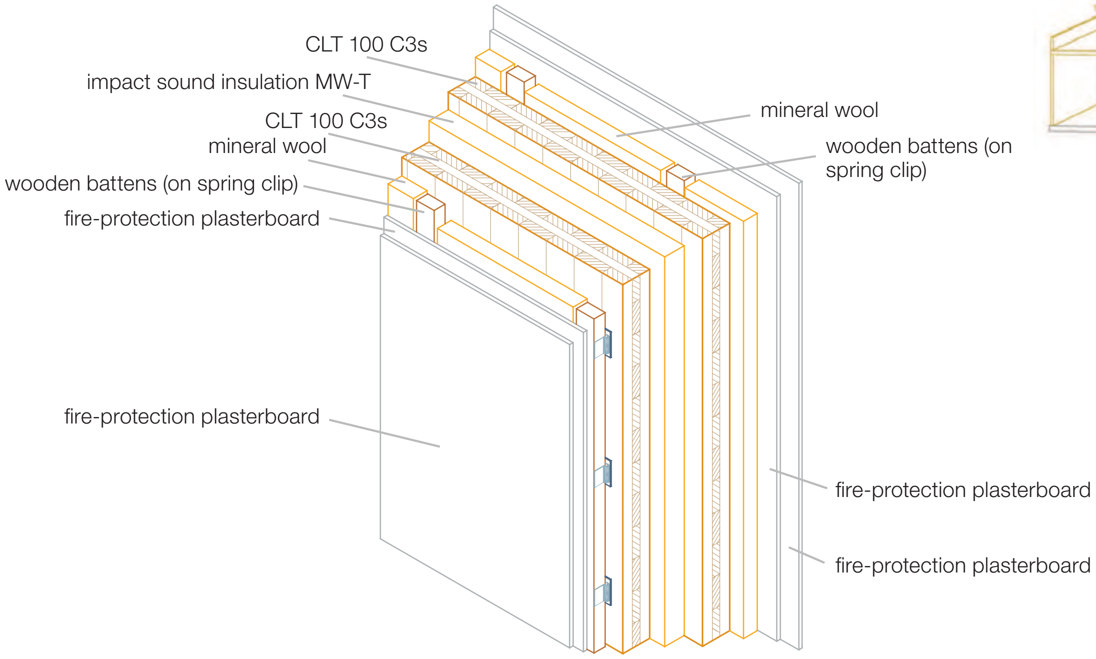
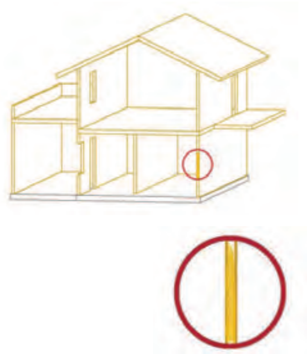
3.16 Partition wall

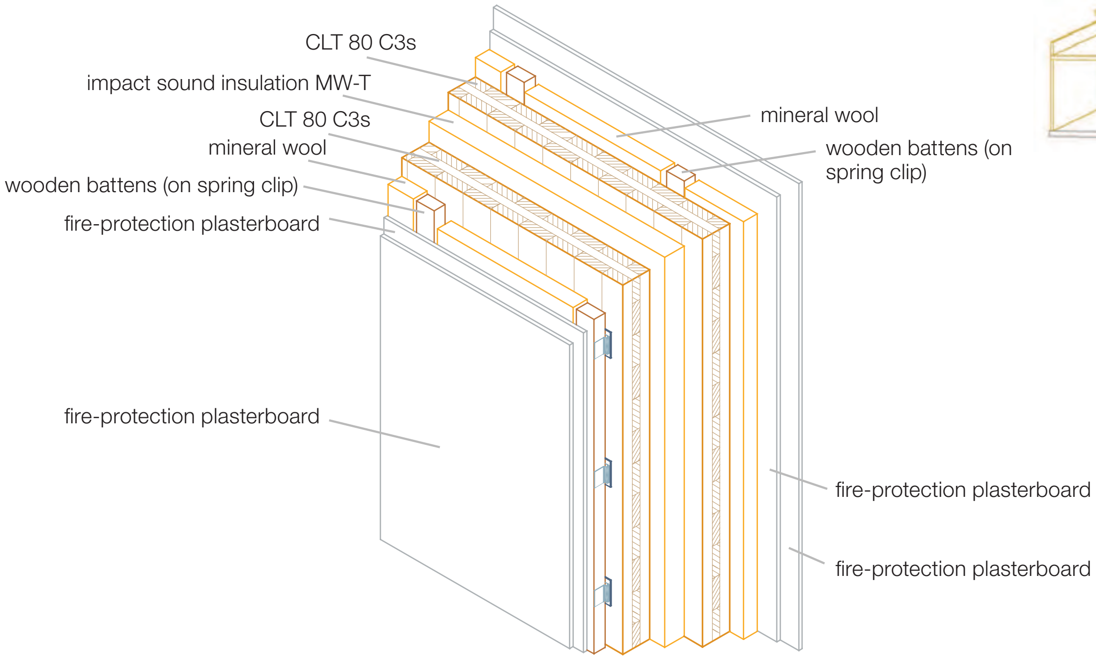


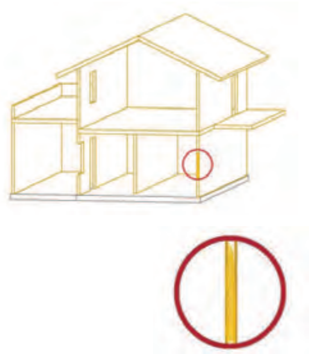


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	2.5	0.250		800	A2
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035	1	18	A1
CLT 100 C3s	10	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
CLT 100 C3s	10	0.110	50	470	D
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035	1	18	A1
Fire-protection plasterboard	2.5	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
2 x 7 + 6	REI 120	35	0.14	adequate	23.1	69	

3.17 Partition wall





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Fire-protection plasterboard	2.5	0.250		800	A2
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035	1	18	A1
CLT 80 C3s	8	0.110	50	470	D
Impact sound insulation MW-T	6	0.035	1	68	A1
CLT 80 C3s	8	0.110	50	470	D
Facing wall on spring clip:	7				
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035	1	18	A1
Fire-protection plasterboard	2.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
2 x 7 + 6	REI 90 EI 120	35	0.15	adequate	23.1	68	

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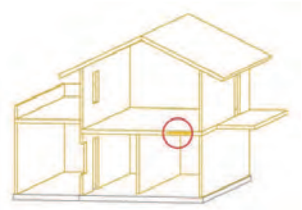
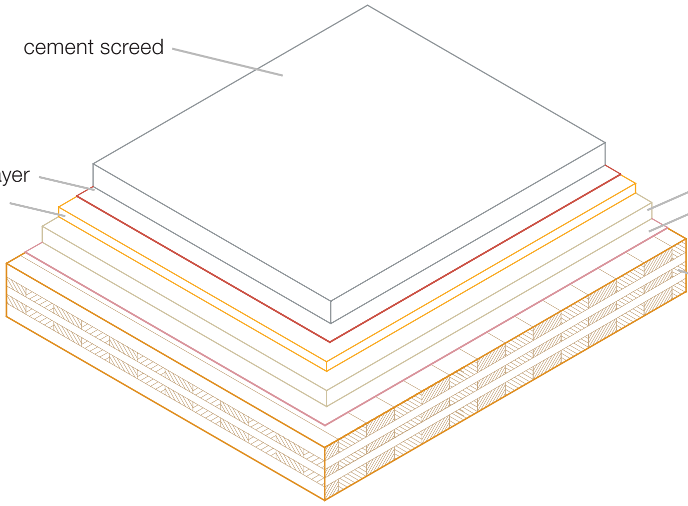
Ceilings

Building physics

Component	Fill	Insulation material	CLT	Slab underside
4.1	Bonded EPS	EPS	CLT 140 L5s	CLT visible quality
4.2	Bonded EPS	EPS	CLT 140 L5s	Panelled with GKF plasterboard
4.3	Bonded EPS	EPS	CLT 140 L5s	Suspended ceiling with GKF plasterboard
4.4	Gravel	Mineral wool for sound insulation	CLT 140 L5s	CLT visible quality
4.5	Gravel	Mineral wool for sound insulation	CLT 140 L5s	Panelled with GKF plasterboard
4.6	Gravel	Mineral wool for sound insulation	CLT 140 L5s	Suspended ceiling with GKF plasterboard

4.1 Floor slab





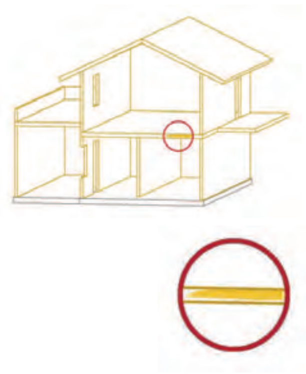
Component design

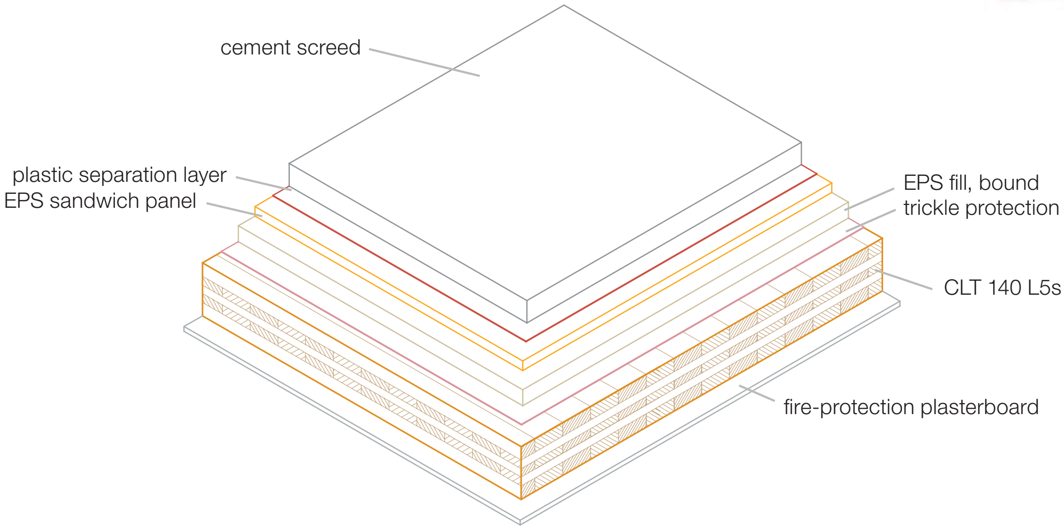
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Cement screed	7	1.330	50-100	2,000	A1
Plastic separation layer		0.200	100,000	1,400	E
EPS sandwich panel	3	0.04	60	18	E
EPS fill, bound	5				
Trickle protection at joints		0.2	423	636	E
CLT 140 L5s	14	0.110	50	470	D

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
8	REI 60	5	0.35	adequate	Inner 32.5 Outer 140.3	55	60

4.2 Floor slab





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Cement screed	7	1.330	50-100	2,000	A1
Plastic separation layer		0.200	100,000	1,400	E
EPS sandwich panel	3	0.04	60	18	E
EPS fill, bound	5				
Trickle protection at joints		0.2	423	636	E
CLT 140 L5s	14	0.110	50	470	D
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
8	REI 90	5	0.35	adequate	Inner 37.7 Outer 140.4	56	59

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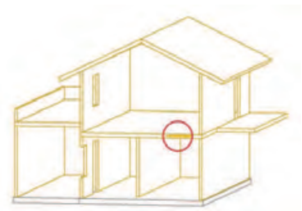
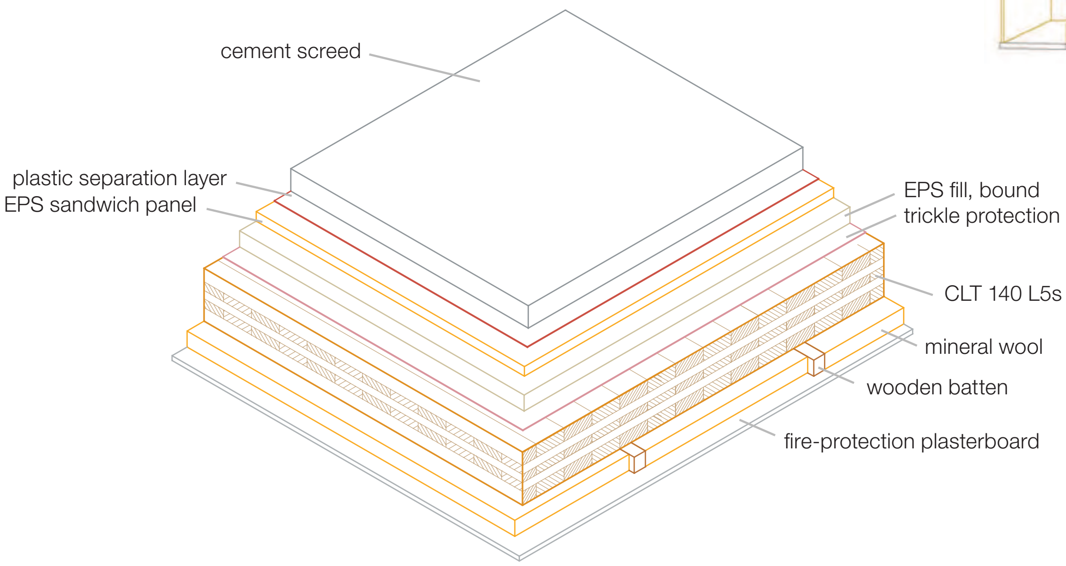
4.3 Floor slab



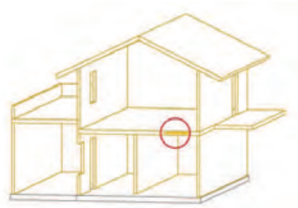


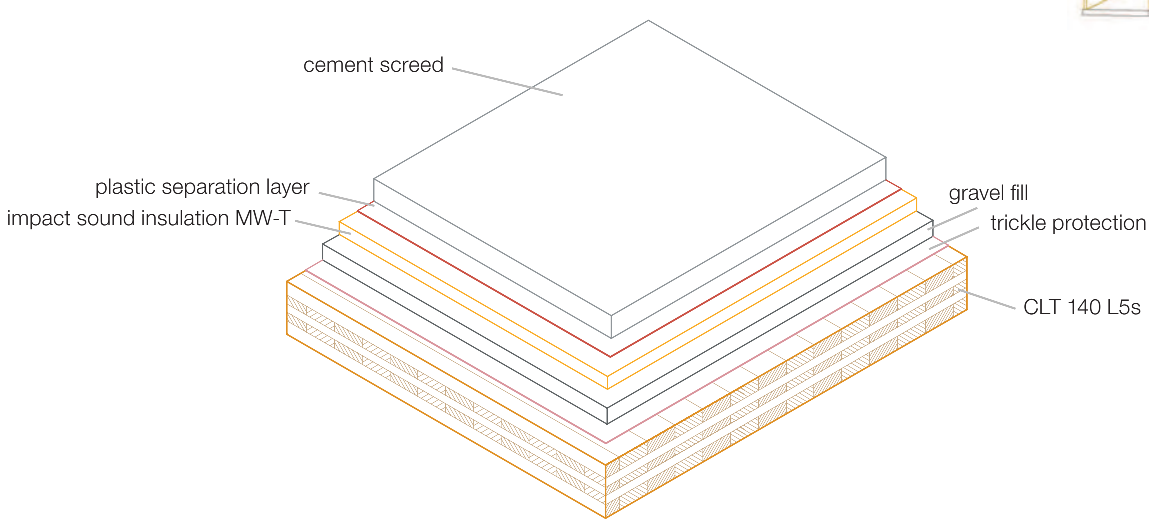
Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Cement screed	7	1.330	50-100	2,000	A1
Plastic separation layer		0.200	100,000	1,400	E
EPS sandwich panel	3	0.04	60	18	E
EPS fill, bound	5				
Trickle protection at joints		0.2	423	636	E
CLT 140 L5s	14	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
8	REI 90	5	0.24	adequate	Inner 16.5 Outer 140.4	60	55

Building physics

4.4 Floor slab





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Cement screed	7	1.330	50-100	2,000	A1
Plastic separation layer		0.200	100,000	1,400	E
Impact sound insulation MW-T	4	0.035	1	68	A1
Gravel fill	5	0.7	2	1,800	A1
Trickle protection at joints		0.2	423	636	E
CLT 140 L5s	14	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
4	REI 60	5	0.37	adequate	Inner 32.0 Outer 139.3	58	51

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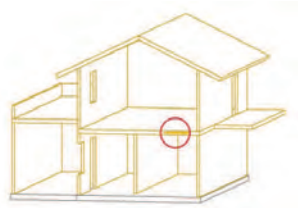
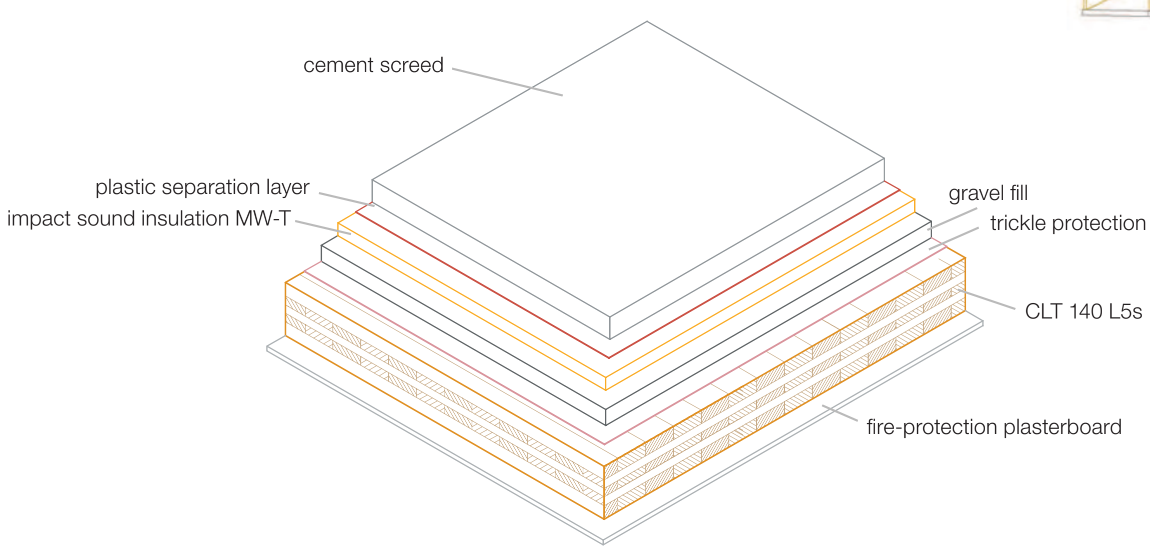
4.5 Floor slab





Component design

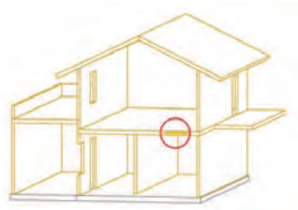
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Cement screed	7	1.330	50-100	2,000	A1
Plastic separation layer		0.200	100,000	1,400	E
Impact sound insulation MW-T	4	0.035	1	68	A1
Gravel fill	5	0.7	2	1,800	A1
Trickle protection at joints		0.2	423	636	E
CLT 140 L5s	14	0.110	50	470	D
Fire-protection plasterboard	1.5	0.250		800	A2

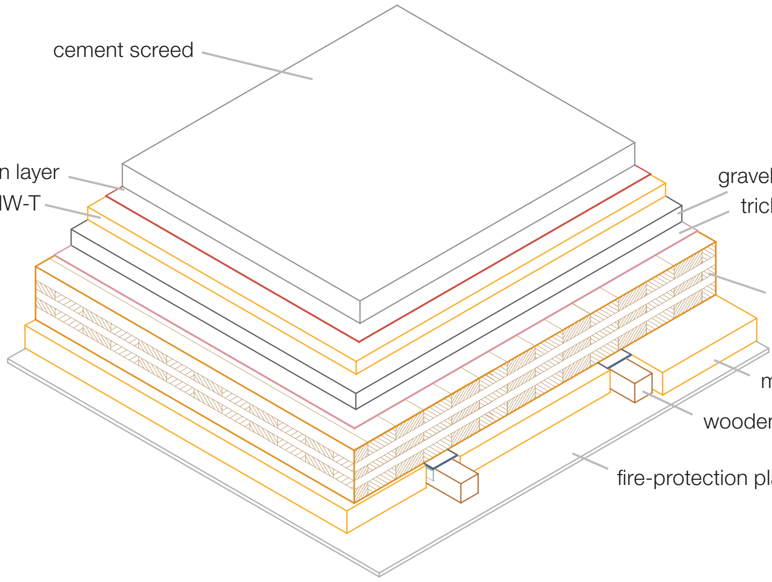
Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
5	REI 90	5	0.36	adequate	Inner 37.5 Outer 139.3	59	50

Building physics

4.6 Floor slab





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Cement screed	7	1.330	50-100	2,000	A1
Plastic separation layer		0.200	100,000	1,400	E
Impact sound insulation MW-T	4	0.035	1	68	A1
Gravel fill	5	0.7	2	1,800	A1
Trickle protection at joints		0.2	423	636	E
CLT 140 L5s	14	0.110	50	470	D
Service cavity on spring clip, comprising:					
Wooden battens 6/6, e = 62.5 cm	6	0.130	50	500	D
Mineral wool	7	0.035	1	18	A1
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
5	REI 90	5	0.23	adequate	Inner 16.4 Outer 139.3	65	45

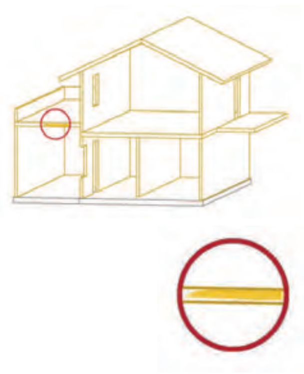
Roofs

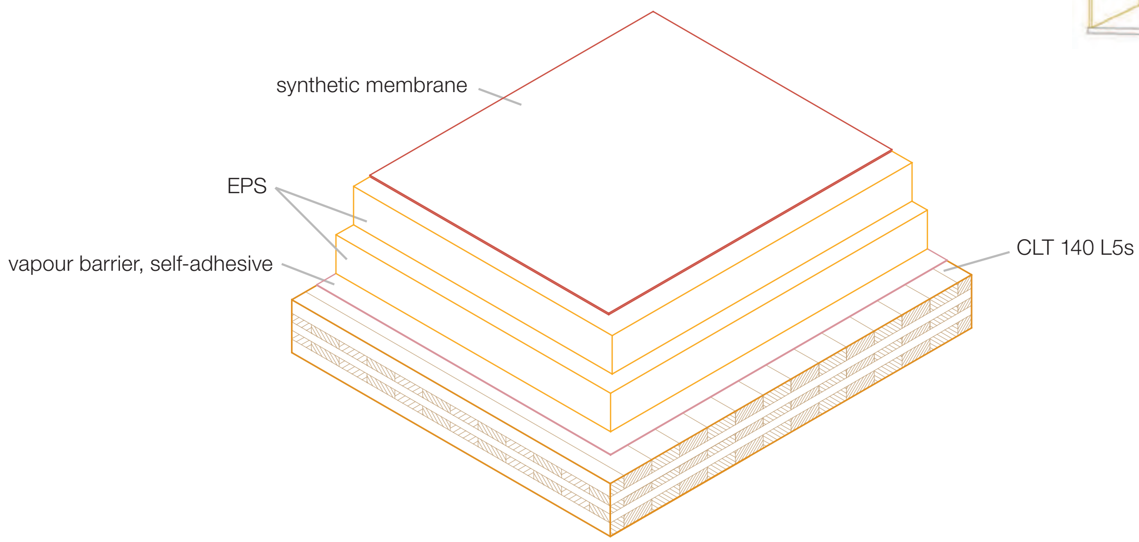
Building physics

Component	Roof covering	Insulation material	CLT	Slab underside
5.1	Foil roof	EPS	CLT 140 L5s	CLT visible quality
5.2	Foil roof	EPS	CLT 140 L5s	Panelled with GKF plasterboard
5.3	Foil roof	EPS	CLT 140 L5s	Suspended ceiling with GKF plasterboard
5.4	Foil roof	Softwood fibre (HWF)	CLT 140 L5s	CLT visible quality
5.5	Foil roof	Softwood fibre (HWF)	CLT 140 L5s	Panelled with GKF plasterboard
5.6	Foil roof	Softwood fibre (HWF)	CLT 140 L5s	Suspended ceiling with GKF plasterboard

Building physics

5.1 Roof





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Synthetic membrane	0.3		40,000	680	E
EPS, 2 layers	24	0.038	60	30	E
Vapour barrier, self-adhesive			1,500		
CLT 140 L5s	14	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
24	REI 60	5	0.13	adequate	32.5	36	

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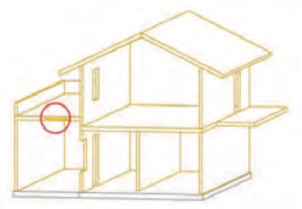
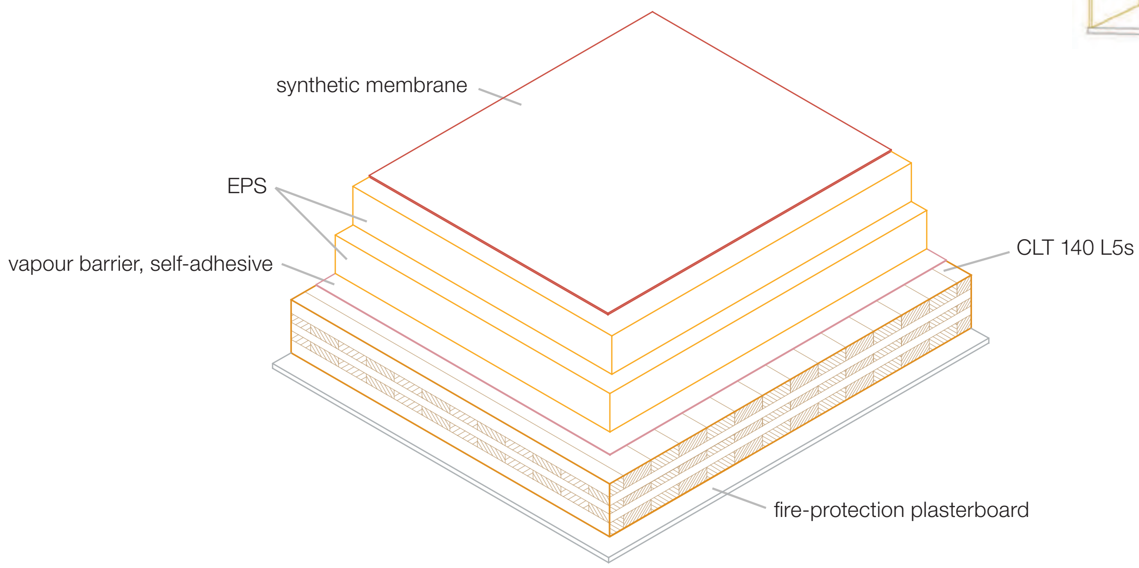
Building physics

5.2 Roof





Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Synthetic membrane	0.3		40,000	680	E
EPS, 2 layers	24	0.038	60	30	E
Vapour barrier, self-adhesive			1,500		
CLT 140 L5s	14	0.110	50	470	D
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
24	REI 90	5	0.13	adequate	36.7	37	

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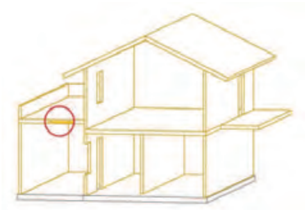
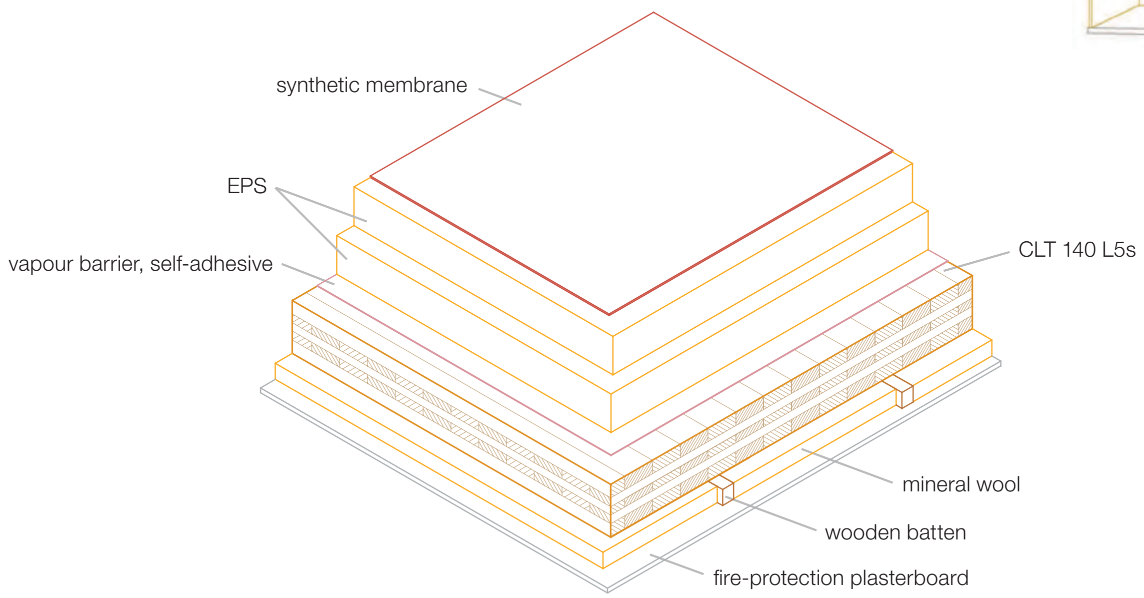
5.3 Roof





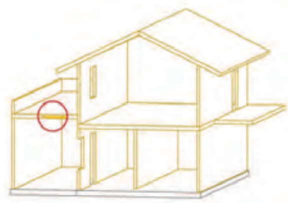
Component design

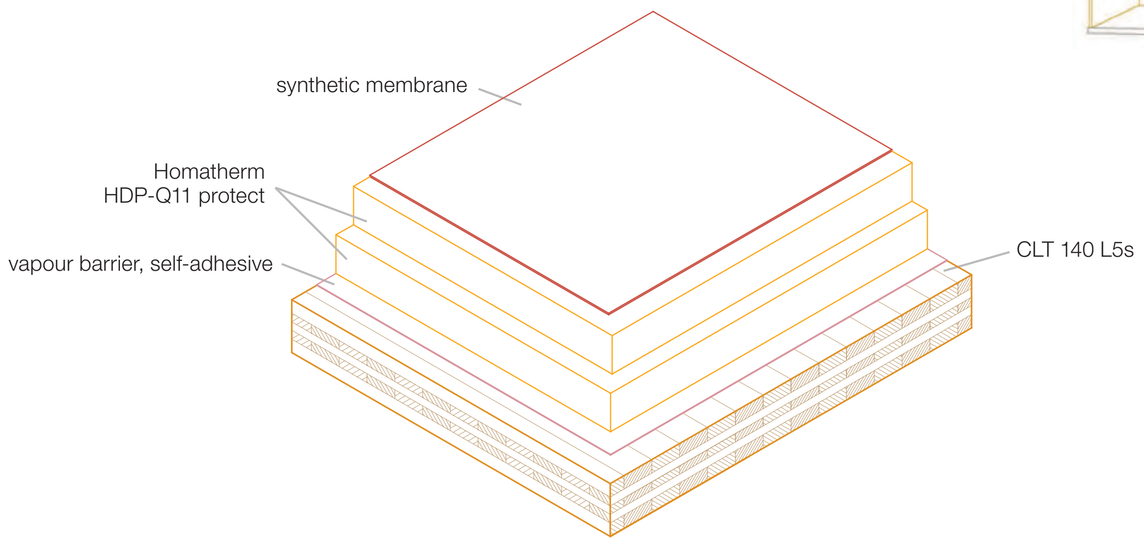
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Synthetic membrane	0.3		40,000	680	E
EPS, 2 layers	24	0.038	60	30	E
Vapour barrier, self-adhesive			1,500		
CLT 140 L5s	14	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
24	REI 90	5	0.11	adequate	14.7	43	

5.4 Roof

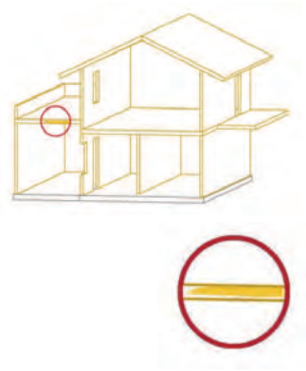


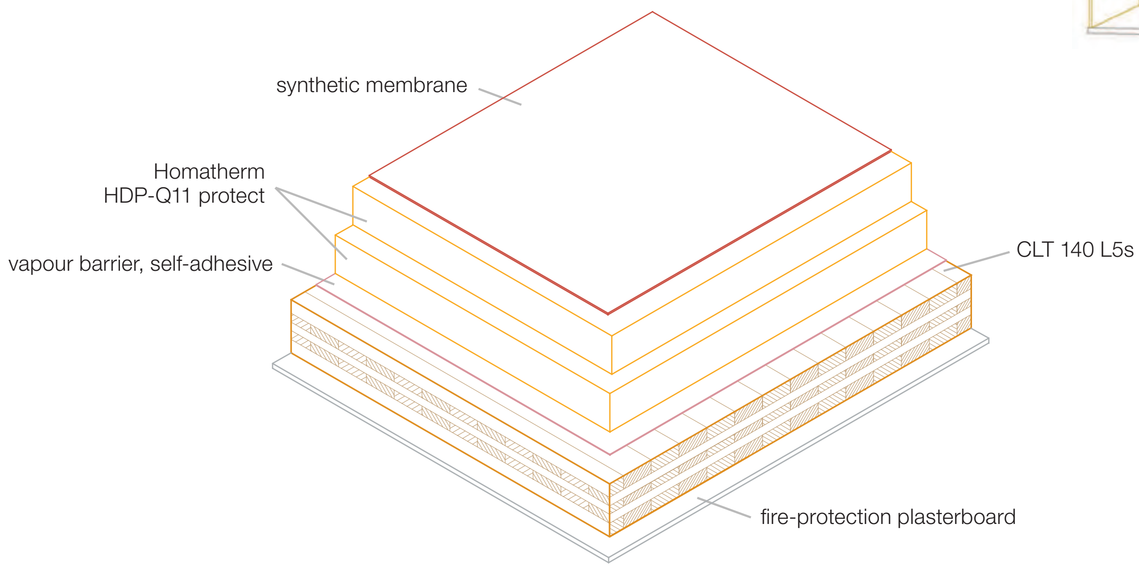


Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Synthetic membrane	0.3		40,000	680	E
Homatherm HDP-Q11 protect, 2 layers	24	0.039	3	140	E
Vapour barrier, self-adhesive			1,500		
CLT 140 L5s	14	0.110	50	470	D

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
24	REI 60	5	0.13	adequate	32.5	38	

5.5 Roof



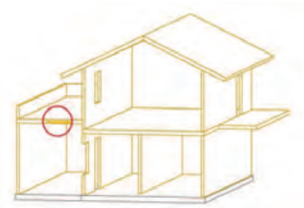


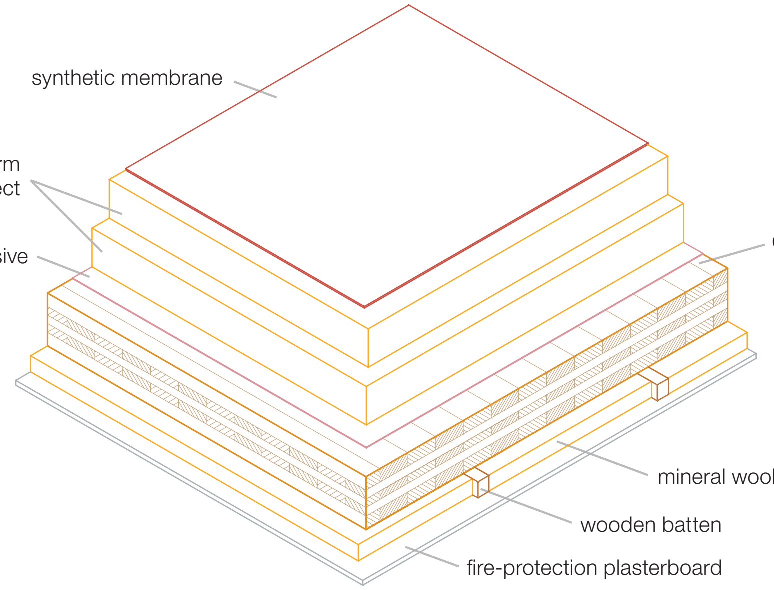
Component design					
Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Synthetic membrane	0.3		40,000	680	E
Homatherm HDP-Q11 protect, 2 layers	24	0.039	3	140	E
Vapour barrier, self-adhesive			1,500		
CLT 140 L5s	14	0.110	50	470	D
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis							
Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
24	REI 90	5	0.13	adequate	36.7	39	

Building physics

5.6 Roof





Component design

Material	Thick. [cm]	λ [W/(mK)]	μ	ρ [kg/m³]	Flamm. cat.
Synthetic membrane	0.3		40,000	680	E
Homatherm HDP-Q11 protect, 2 layers	24	0.039	3	140	E
Vapour barrier, self-adhesive			1,500		
CLT 140 L5s	14	0.110	50	470	D
Service cavity consisting of:					
Wooden battens 40/50, e = 62.5 cm	5	0.130	50	500	D
Mineral wool	5	0.035		18	A1
Fire-protection plasterboard	1.5	0.250		800	A2

Structural-physical analysis

Insul. thick.	Fire protection i → o		Thermal performance			Acoustic performance	
[cm]	Fire resistance	Load [kN/m]	U-value [W/m²K]	Permeability	Thermal mass $m_{w,B,A}$ [kg/m²]	R_w	$L_{n,w}$
24	REI 90	5	0.11	adequate	14.7	45	

Structural analysis

General information about structural engineering with CLT

As the board layers are bonded at right angles to each other, the load is transferred along two axes. In the past, this was the preserve of reinforced steel structures. The advantage of this is a more flexible interior design at the planning stage; designs can now also be simplified, and lower slab ceiling heights are possible. Although diagonally projecting or point-supported structures require more planning, they are perfectly feasible. CLT panels have a particularly high load capacity as the load-bearing width generally extends across the entire panel width due to the transverse layers. The high inherent rigidity of CLT also has a positive impact on bracing a building.

CLT calculation method

The difference to dimensioning solid wood or glued laminated timber lies in the loading of the transverse layers. In a CLT panel, a load at right angles to the panel plane (e.g. a snow load on a flat roof) generates a shear load in the transverse layers which acts at right angles to the grain. This shear load is termed rolling shear as the wood fibres “roll off” at right angles in the event of a fracture. As a result of the low shear strength or resistance of the transverse layer (load at right angles to the grain), the stresses or deformations that occur cannot be ignored. Calculations are carried out in accordance with the lamination theory, taking account of shear distortions. Various options now exist for calculating cross-laminated timber; one of these is the “theory of flexibly connected layers” (also termed the “gamma method”). The gamma method is the most common method and is also described in ETA-08/0271.

Fasteners

Verification of the fasteners is described and regulated in the approvals.

Structural analysis

A. Calculating CLT

The particular feature when calculating CLT lies in the fact that the transverse layers represent low-shear layers. As a result, the deflection caused by transverse loads and "rolling shear" can no longer be ignored. Various calculation methods have been developed for this. These methods are outlined briefly below, and the publications containing full details are listed. In the structural analysis, CLT/cross-laminated timber cannot be regarded and treated in the same way as solid wood or glued laminated timber.

Stora Enso offers a structural analysis program free of charge on www.clt.info. This can be used to verify common CLT components.

A.1. Calculation based on the lamination theory

A.1.1. With the aid of "panel design factors"

This calculation method does not take account of deflection as a result of transverse loads and therefore only applies to relatively large span/thickness ratios (approx. > 30). For symmetrical panel designs, [1] and [2] contain formulae for calculating EJ_{ef} in panels and disks.

A.1.2. With the aid of the "shear correction coefficient"

This method enables ceiling deflection to be determined by calculating the shear correction coefficient for the relevant cross-sectional structure. Fusing framework programs, which take account of deflection as a result of transverse loads, CLT can be calculated with sufficient accuracy. The method is presented in [3].

A.2. Calculation based on the γ method

This method was developed to analyse flexibly-connected flexural girders (see [4] and [5]) and can also be applied to CLT. The method is sufficiently accurate for practical building operations and is described in [2] for use with cross-laminated timber.

This method is also defined in various timber construction standards, e.g. in DIN 1052-1:1988, DIN 1052:2008, ÖNORM B 4100-2:2003 and in EC 5, EN 1995-1-1.

A.3. Calculation based on the shear analogy method

The shear analogy method is described in DIN 1052-1:2008, appendix D and is regarded as a precise method for calculating cross-laminated timber with any layer structures. [2] contains a brief explanation, while a more detailed description is given in [6], [7], [8] and [9]. The process is relatively complex compared to those described above.

A.4. A. Twin-axis calculation of CLT

A.1.1. With the aid of grillages

2D structures can be modelled with the aid of framework programs. Individual references can be found in [10] and [11], and more detailed information in [9].

A.4.2. With the aid of FEM programs

2D structures can be modelled with the aid of FEM programs. Information can be found in [9] and [12].

B. Calculation of fasteners in CLT

The calculation of fasteners is described in approval Z-9.1-559 for CLT. Detailed descriptions of pin-type fasteners can be found in [13] and [14].

Literature cited:

[1] Blaß H. J., Fellmoser P.: Bemessung von Mehrschichtplatten [***Dimensioning multi-layer panels***]. In: Bauen mit Holz 105 [***Building with wood***] 105 (2003), issue 8, pp. 36-39, issue 9, pp. 37-39 or download: www.holz.uni-karlsruhe.de under Veröffentlichungen [***Publications***] (status: 10/2008)

[2] Blaß H. J., Görlacher R.: Brettsperrholz - Berechnungsgrundlagen [***Cross-laminated timber - Calculation principles***]. In: Holzbaukalender [***Wooden structure diary***] 2003, pp. 580 - 59. Publishers: Bruderverlag Karlsruhe 2003.

[3] Jöbstl R.: Praxisgerechte Bemessung von Brettsperrholz [***Practical dimensioning of cross-laminated timber***]. In: Ingenieurholzbau, Karlsruher Tage [***Timber engineering, Karlsruhe Conference***] 2007. Publishers: Bruderverlag Karlsruhe 2007.

[4] Schelling W.: Zur Berechnung nachgiebig zusammengesetzter Biegeträger aus beliebig vielen Einzelquerschnitten [***Designing flexibly laminated flexing beams made of any number of individual cross-sections*].** In: Ehlbeck, J. (ed.); Steck, G. (ed.): Ingenieurholzbau in Forschung und Praxis [***Timber engineering in research and practice***]. Publishers: Bruderverlag Karlsruhe 1982.

[5] Heimeshoff B.: Zur Berechnung von Biegeträgern aus nachgiebig miteinander verbundenen Querschnittsteilen im Ingenieurholzbau [***Calculation of flexing beams comprising flexibly-connected cross-sections in timber engineering***]. In: Holz als Roh- und Werkstoff [***Wood as a raw material***] 45 (1987) pp. 237-241; 1987.

[6] Kreuzinger H.: Platten, Scheiben und Schalen [***Panels, disks and shells***]. In: Bauen mit Holz [***Building with wood***] 1/99, pp. 34-39; 1999.

[7] Blaß H.J., Ehlbeck J., Kreuzinger H., Steck G.: Erläuterungen zu DIN 1052:2004-08 [***Explanations on DIN 1052:2004-08***], pp. 52-56 and 81-84; publishers: Bruderverlag Karlsruhe 2004.

[8] Scholz A.: Schubanalogie in der Praxis [***Shear analogy in practice***]. Möglichkeiten und Grenzen. [Opportunities and limitations]. In: Ingenieurholzbau, Karlsruher Tage 2004 [***Timber engineering, Karlsruhe Conference 2004***]. Publishers: Bruderverlag Karlsruhe 2007.

[9] Winter S., Kreuzinger H., Mestek P.: TP 15 Flächen aus Brettstapeln, Brettsperrholz und Verbundkonstruktionen [***TP 15 surfaces made of glue-laminated and cross-laminated timber and laminated structures***]. Technical University of Munich 2008.

[10] Various authors: Mehrgeschossiger Holzbau in Österreich: Holzskelett- und Holzmassivbauweise [***Multi-storey wood engineering in Austria: timber frame and solid timber structures***]. pp.127-128; Publishers: ProHolz Austria, Vienna 2002.

[11] Schrentewein T.: Konzentration auf den Punkt [***Concentrating on the point***]. In: Bauen mit Holz [***Building with wood***] 1/2008, pp. 43-47; 2008.

[12] Bogensperger T., Pürgstaller A.: Modellierung von Strukturen aus Brettsperrholz unter Berücksichtigung der Verbindungstechnik [***Modelling cross-laminated timber structures with reference to fastening systems***]. In: Tagungsband der 7. Grazer Holzbau-Fachtagung [***Proceedings of 7th Graz Timber Engineering Conference***]; 2008.

[13] Uibel T.: Brettsperrholz - Verbindungen mit mechanischen Verbindungsmitteln [***Cross-laminated timber - connections using mechanical fasteners***]. In: Ingenieurholzbau, Karlsruher Tage 2007 [***Timber engineering, Karlsruhe Conference 2007***]. Publishers: Bruderverlag Karlsruhe 2007.

[14] Blaß H. J., Uibel T.: Tragfähigkeit von stiftförmigen Verbindungsmitteln in Brettsperrholz [***Load capacity of pin-type fasteners in cross-laminated timber***]. Karlsruher Berichte zum Ingenieurholzbau [***Karlsruhe report on timber engineering***] - Vol. 8 (2007).

Structural analysis

CLT - STRUCTURAL ANALYSIS PROGRAM 04/**2012**

In conjunction with WallnerMild Holz·Bau·Software©, Stora Enso can provide you with a free-of-charge design program for CLT. The CLT design program can be downloaded **free of charge** from **www.clt.info** and is available in various languages.

System requirements

- Microsoft Excel 11.0 (Office 2003)

The software suite has been designed and tested for the above version of Excel. The structural analysis program should also run with Excel 10.0 (Office XP) to Excel 12.0 (Office 2010).

Initial installation

Double-click the Setup icon to start the installation automatically.

During the installation process, Excel must be closed and the user should have full administrator rights.

It should also be noted that links between "*.xls" files and OpenOffice can cause problems.

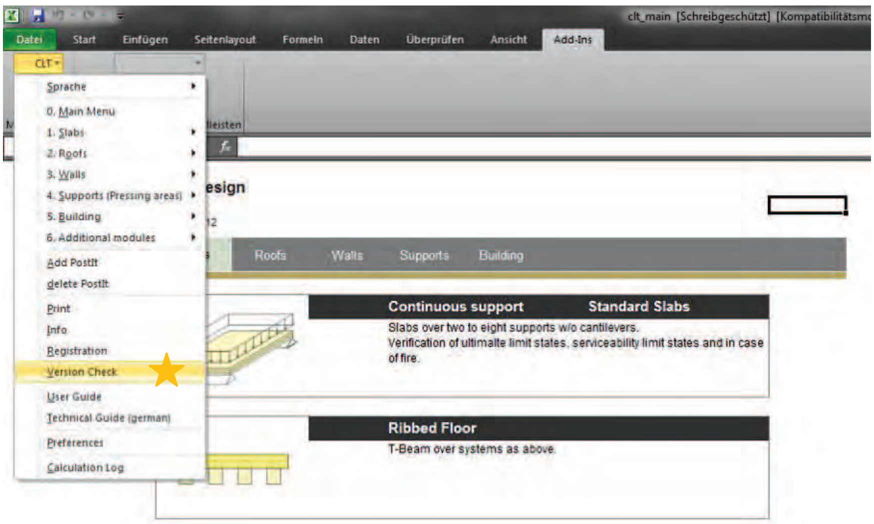
With some computers, problems can also occur with add-ins that are not authorised by Windows. "Add-ins" form part of the software suite and must be authorised in order to be activated. This process depends on the operating system and should be checked on a case by case basis.

Registration

The sole purpose of this registration is to give Stora Enso an overview of the program's distribution so that the user can be given appropriate advice in every regard and can be kept informed of new features.

Version check

If the CLT design program is already installed and the user would like to update the program, the version check can be launched via the menu bar.



You will then be directed to www.bemessung.com, and a link for the new version will be emailed to you.

During the installation process, Excel must be closed again and the user should have full administrator rights.

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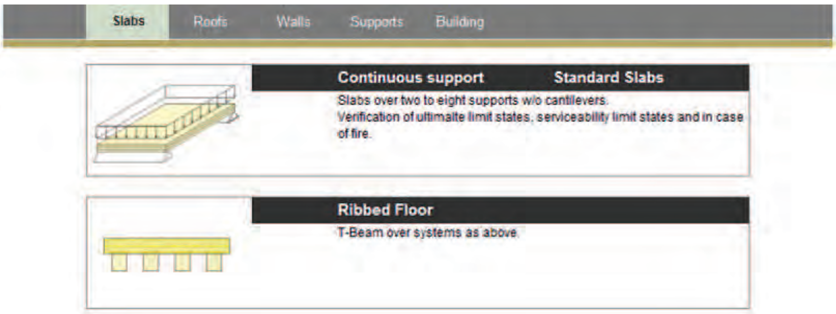
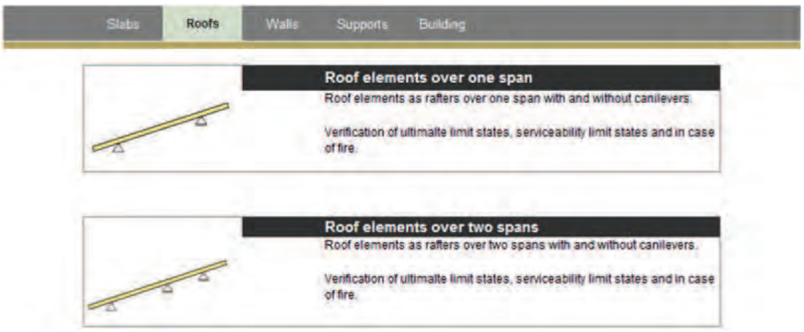
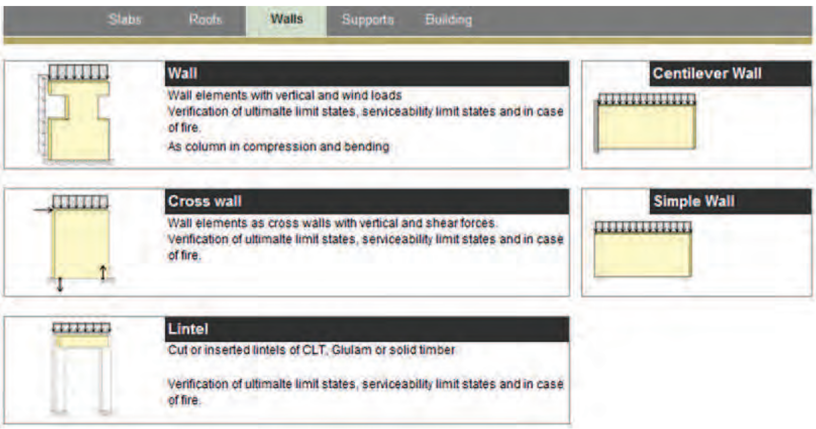
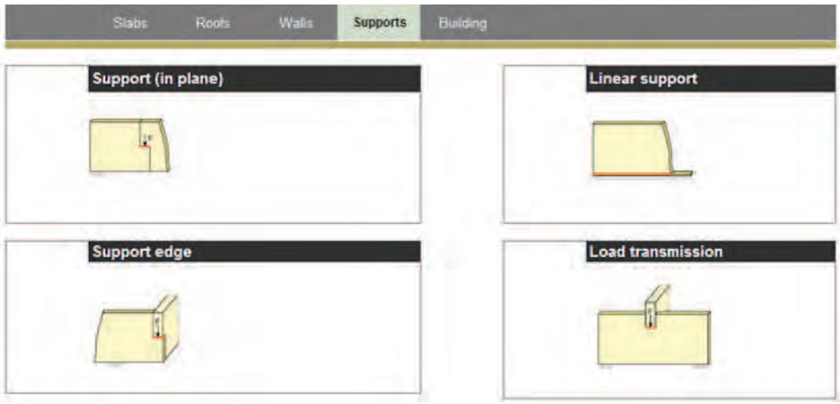
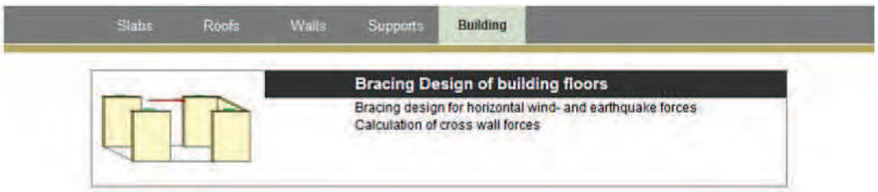
The following modules are available to you in the design program:











CLT preliminary estimate tables

The preliminary estimate tables shown on the next few pages have been compiled by Stora Enso in good faith but are not a substitute for a structural analysis for particular applications or circumstances. All the information contained in the tables complies with the latest state of the art technology, however, errors cannot be ruled out.

Stora Enso shall therefore accept no liability and explicitly states that users of these preliminary estimate tables are responsible for checking the individual results.

Structural analysis

INTERNAL WALLS 04/**2012**

Internal walls (no wind pressure)

In accordance with approval Z 9.1-559
DIN 1052 (2008) and/or EN 1995-1-1 (2006)

<table>
<tr><th rowspan="3">Dead weight
gk*)</th><th rowspan="3">Imposed load
nk</th><th colspan="12">Height (buckling length)</th></tr>
<tr><th colspan="4">2,50 m</th><th colspan="4">3,00 m</th><th colspan="4">4,00 m</th></tr>
<tr><th>R 0</th><th>R 30</th><th>R 60</th><th>R 90</th><th>R 0</th><th>R 30</th><th>R 60</th><th>R 90</th><th>R 0</th><th>R 30</th><th>R 60</th><th>R 90</th></tr>
<tr><td rowspan="6">10,00</td><td>10,00</td><td rowspan="6">60 C3s</td><td rowspan="6">80 C3s</td><td rowspan="2">80 C3s</td><td>100 C3s</td><td rowspan="4">60 C3s</td><td rowspan="6">80 C3s</td><td>80 C3s</td><td rowspan="4">120 C3s</td><td rowspan="2">60 C3s</td><td rowspan="3">80 C3s</td><td rowspan="3">100 C5s</td><td>120 C3s</td></tr>
<tr><td>20,00</td><td rowspan="5">120 C3s</td><td rowspan="5">100 C5s</td><td rowspan="5">140 C5s</td></tr>
<tr><td>30,00</td><td rowspan="4">100 C5s</td><td rowspan="4">80 C3s</td></tr>
<tr><td>40,00</td><td>90 C3s</td><td rowspan="3">120 C5s</td></tr>
<tr><td>50,00</td><td rowspan="2">80 C3s</td><td rowspan="2">140 C5s</td><td rowspan="2">100 C3s</td></tr>
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<tr><td rowspan="6">20,00</td><td>10,00</td><td rowspan="5">60 C3s</td><td rowspan="6">80 C3s</td><td>80 C3s</td><td rowspan="5">120 C3s</td><td rowspan="3">60 C3s</td><td rowspan="5">80 C3s</td><td rowspan="5">100 C5s</td><td rowspan="3">120 C3s</td><td>60 C3s</td><td rowspan="2">80 C3s</td><td rowspan="2">100 C5s</td><td>120 C3s</td></tr>
<tr><td>20,00</td><td rowspan="5">100 C5s</td><td rowspan="4">80 C3s</td><td rowspan="5">140 C5s</td></tr>
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<tr><td>50,00</td></tr>
<tr><td>60,00</td><td>80 C3s</td><td>140 C5s</td><td>90 C3s</td><td>120 C5s</td><td>90 C3s</td><td>100 C5s</td></tr>
<tr><td rowspan="6">30,00</td><td>10,00</td><td rowspan="4">60 C3s</td><td rowspan="6">80 C3s</td><td rowspan="6">100 C5s</td><td rowspan="4">120 C3s</td><td rowspan="2">60 C3s</td><td rowspan="4">80 C3s</td><td rowspan="4">100 C5s</td><td rowspan="2">120 C3s</td><td rowspan="4">80 C3s</td><td>80 C3s</td><td>100 C5s</td><td rowspan="6">140 C5s</td></tr>
<tr><td>20,00</td><td>90 C3s</td><td rowspan="5">120 C5s</td></tr>
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<tr><td>50,00</td><td rowspan="2">80 C3s</td><td rowspan="2">140 C5s</td><td rowspan="2">90 C3s</td><td rowspan="2">120 C5s</td><td rowspan="2">90 C3s</td><td rowspan="2">100 C5s</td></tr>
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<tr><td rowspan="6">40,00</td><td>10,00</td><td rowspan="3">60 C3s</td><td rowspan="6">80 C3s</td><td rowspan="6">100 C5s</td><td rowspan="3">120 C3s</td><td>60 C3s</td><td rowspan="3">80 C3s</td><td rowspan="3">100 C5s</td><td>120 C3s</td><td rowspan="3">80 C3s</td><td>90 C3s</td><td rowspan="6">120 C5s</td><td rowspan="6">140 C5s</td></tr>
<tr><td>20,00</td><td rowspan="5">80 C3s</td><td rowspan="5">140 C5s</td><td rowspan="2">100 C3s</td></tr>
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<tr><td>60,00</td><td>120 C3s</td></tr>
<tr><td rowspan="6">50,00</td><td>10,00</td><td rowspan="2">60 C3s</td><td rowspan="5">80 C3s</td><td rowspan="6">100 C5s</td><td rowspan="3">120 C3s</td><td rowspan="6">80 C3s</td><td rowspan="2">80 C3s</td><td rowspan="3">100 C5s</td><td rowspan="6">140 C5s</td><td rowspan="2">80 C3s</td><td>90 C3s</td><td rowspan="6">120 C5s</td><td rowspan="6">140 C5s</td></tr>
<tr><td>20,00</td><td rowspan="2">100 C3s</td></tr>
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<tr><td>50,00</td><td rowspan="2">120 C3s</td></tr>
<tr><td>60,00</td><td>90 C3s</td><td>100 C3s</td><td>100 C3s</td></tr>
<tr><td rowspan="6">60,00</td><td>10,00</td><td>60 C3s</td><td rowspan="4">80 C3s</td><td rowspan="5">100 C5s</td><td rowspan="2">120 C3s</td><td rowspan="6">80 C3s</td><td>80 C3s</td><td rowspan="2">100 C5s</td><td rowspan="6">140 C5s</td><td>80 C3s</td><td rowspan="2">100 C3s</td><td rowspan="6">120 C5s</td><td rowspan="6">140 C5s</td></tr>
<tr><td>20,00</td><td rowspan="5">80 C3s</td><td rowspan="3">90 C3s</td><td rowspan="3">90 C3s</td></tr>
<tr><td>30,00</td><td rowspan="4">140 C5s</td><td rowspan="4">120 C5s</td><td>100 C5s</td></tr>
<tr><td>40,00</td><td rowspan="3">120 C3s</td></tr>
<tr><td>50,00</td><td rowspan="2">90 C3s</td><td rowspan="2">100 C3s</td><td rowspan="2">100 C3s</td></tr>
<tr><td>60,00</td><td>120 C5s</td></tr>
</table>

* The CLT self-weight is already taken into account in the table at ρ = 500 kg/m³!

Service class 1, imposed load category A ($\psi_0 = 0.7$; $\psi_1 = 0.5$; $\psi_2 = 0.3$)

Load-bearing capacity:
a) Verification as a column (compression in accordance w ith equivalent member method)
b) Shearing stresses

kmod = 0.8

Fire resistance
v1,i = 0.63 mm/min
v1,a = 0.86 mm/min

R0
R30
R60
R90

This table is only for preliminary estimate purposes and is not a substitute for a structural analysis.

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Structural analysis

EXTERNAL WALLS 04/2012

External walls (w = 1.00 kN/m²)

In accordance with approval Z 9.1-559
DIN 1052 (2008) and/or EN 1995-1-1 (2006)

Dead weight gk*)	Imposed load nk	Height (buckling length) 2,50 m R 0	2,50 m R 30	2,50 m R 60	2,50 m R 90	3,00 m R 0	3,00 m R 30	3,00 m R 60	3,00 m R 90	4,00 m R 0	4,00 m R 30	4,00 m R 60	4,00 m R 90
10,00	10,00			80 C3s						60 C3s	80 C3s	100 C5s	120 C3s
	20,00					60 C3s			120 C3s				
	30,00	60 C3s	80 C3s		120 C3s		80 C3s	100 C5s		80 C3s	90 C3s		
	40,00			100 C5s							100 C3s	120 C5s	140 C5s
	50,00					80 C3s			140 C5s				
	60,00	80 C3s					90 C3s			90 C3s	100 C5s		
20,00	10,00			80 C3s		60 C3s			120 C3s		80 C3s	100 C5s	
	20,00	60 C3s					80 C3s			80 C3s	90 C3s		
	30,00		80 C3s		120 C3s			100 C5s			100 C3s		140 C5s
	40,00			100 C5s		80 C3s			140 C5s			120 C5s	
	50,00	80 C3s					90 C3s			90 C3s	100 C5s		
	60,00				140 C5s			120 C5s					
30,00	10,00					60 C3s			120 C3s		90 C3s		
	20,00	60 C3s			120 C3s		80 C3s	100 C5s		80 C3s	100 C3s		
	30,00		80 C3s	100 C5s								120 C5s	140 C5s
	40,00					80 C3s			140 C5s				
	50,00	80 C3s			140 C5s		90 C3s	120 C5s		90 C3s	100 C5s		
	60,00												
40,00	10,00					60 C3s	80 C3s		120 C3s	80 C3s	90 C3s		
	20,00	60 C3s			120 C3s			100 C5s			100 C3s		
	30,00		80 C3s	100 C5s								120 C5s	140 C5s
	40,00					80 C3s	90 C3s		140 C5s	90 C3s	100 C5s		
	50,00	80 C3s			140 C5s			120 C5s					
	60,00		90 C3s				100 C3s			100 C3s	120 C3s		
50,00	10,00	60 C3s			120 C3s		80 C3s	100 C5s		80 C3s	100 C3s		
	20,00		80 C3s										
	30,00			100 C5s		80 C3s	90 C3s		140 C5s	90 C3s	100 C5s	120 C5s	140 C5s
	40,00	80 C3s			140 C5s			120 C5s					
	50,00		90 C3s				100 C3s			100 C3s	120 C3s		
	60,00			120 C5s									
60,00	10,00	60 C3s			120 C3s			100 C5s			100 C3s		
	20,00		80 C3s	100 C5s			90 C3s			90 C3s	100 C5s		
	30,00					80 C3s			140 C5s			120 C5s	140 C5s
	40,00	80 C3s			140 C5s			120 C5s					
	50,00		90 C3s	120 C5s			100 C3s			100 C3s	120 C3s		
	60,00												160 C5s

* The CLT self-weight is already taken into account in the table at ρ = 500 kg/m³!

Service class 1, imposed load category A (ψ_0 = 0.7; ψ_1 = 0.5; ψ_2 = 0.3)

Load-bearing capacity:
a) Verification as a column (compression in accordance with equivalent member method)
b) Shearing stresses

kmod = 0.8

Fire resistance
v1,i = 0.63 mm/min
v1,a = 0.86 mm/min

R0
R30
R60
R90

This table is only for preliminary estimate purposes and is not a substitute for a structural analysis.

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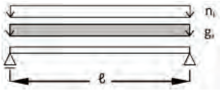
Structural analysis



Single-span beam_Vibration

In accordance with approval Z 9.1-559
DIN 1052 (2008) and/or EN 1995-1-1 (2006)

Dead weight gk*)	Imposed load nk	Span of single-span beam								
		3,00 m	3,50 m	4,00 m	4,50 m	5,00 m	5,50 m	6,00 m	6,50 m	7,00 m
1,00	1,00		80 L3s	90 L3s		120 L3s	140 L5s	160 L5s – 2	180 L5s	
	2,00	80 L3s	90 L3s	100 L3s	120 L3s	120 L3s			200 L5s	220 L7s – 2
	2,80							180 L5s		
	3,50	80 L3s	90 L3s	120 L3s	120 L3s	140 L5s	160 L5s – 2			
	4,00		100 L3s		140 L5s			200 L5s	220 L7s – 2	240 L7s – 2
	5,00	90 L3s	120 L3s	120 L3s		160 L5s – 2				
1,50	1,00	80 L3s	90 L3s	100 L3s	120 L3s			180 L5s	200 L5s	220 L7s – 2
	2,00					140 L5s				
	2,80	80 L3s		120 L3s	120 L3s		160 L5s – 2			
	3,50		100 L3s					200 L5s	220 L7s – 2	240 L7s – 2
	4,00	90 L3s		120 L3s	140 L5s	160 L5s – 2				
	5,00	90 L3s	120 L3s				180 L5s	220 L7s – 2		
2,00	1,00	80 L3s			120 L3s	140 L5s	160 L5s – 2			
	2,00		100 L3s	120 L3s				200 L5s		
	2,80	90 L3s							220 L7s – 2	240 L7s – 2
	3,50				140 L5s	160 L5s – 2	180 L5s			
	4,00	90 L3s	120 L3s	120 L3s				220 L7s – 2		
	5,00						200 L5s		240 L7s – 2	260 L7s – 2
2,50	1,00	90 L3s	100 L3s	120 L3s			160 L5s – 2	200 L5s		
	2,00						180 L5s		220 L7s – 2	240 L7s – 2
	2,80		120 L3s	120 L3s	140 L5s	160 L5s – 2				
	3,50	90 L3s						220 L7s – 2		
	4,00			140 L5s			200 L5s		240 L7s – 2	260 L7s – 2
	5,00	100 L3s	120 L3s		160 L5s – 2					
3,00	1,00	90 L3s		120 L3s	140 L5s		180 L5s		220 L7s – 2	240 L7s – 2
	2,00	90 L3s	120 L3s							
	2,80					160 L5s – 2		220 L7s – 2		260 L7s – 2
	3,50	100 L3s		140 L5s	160 L5s – 2		200 L5s		240 L7s – 2	
	4,00		120 L3s							
	5,00					180 L5s				280 L7s – 2

* The CLT self-weight is already taken into account in the table at ρ = 500 kg/m³!

Service class 1, imposed load category A ($\psi_0 = 0.7$; $\psi_1 = 0.5$; $\psi_2 = 0.3$)

Load-bearing capacity:
a) Verification of bending stresses
b) Verification of shearing stresses

kmod = 0.8

Serviceability:
a) Quasi-constant design situation
zul w fin = 250
b) Infrequent design situation:
zul w q,inst = 300
zul w fin - w g,inst = 200
c) Vibration
Vibration according to EN 1995-1-1 and Kreuzinger & Mohr
($f_1 > 8$ Hz or $f_1 > 5$ Hz with a = 0.4m/s², $v < v_{grenz}$, $w_{EF} < 1$ mm)
D = 2%, 5 cm cement screed, b = 1.2 · ℓ

kdef = 0.6

Fire resistance
HFA 2011
v1 = 0.65 mm/min

R0
R30
R60
R90

Since any vibration depends not only on the span but also on the mass, a thicker ceiling may be necessary despite a shorter span.

This table specifies the required thicknesses for the normal design situation (R0). The colour shading represents the fire resistance time which is also attained with this thickness. If a higher fire resistance time is required, a separate analysis must be carried out.

This table is only for preliminary estimate purposes and is not a substitute for a structural analysis.

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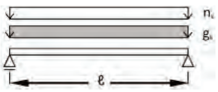
Structural analysis

SINGLE-SPAN BEAM - DEFORMATION 04/2012



Single-span beam_deformation

In accordance with approval Z 9.1-559
DIN 1052 (2008) and/or EN 1995-1-1 (2006)

<table>
<tr><th rowspan="2">Dead weight
gk*)</th><th rowspan="2">Imposed load
nk</th><th colspan="9">Span of single-span beam</th></tr>
<tr><th>3,00 m</th><th>3,50 m</th><th>4,00 m</th><th>4,50 m</th><th>5,00 m</th><th>5,50 m</th><th>6,00 m</th><th>6,50 m</th><th>7,00 m</th></tr>
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</table>

* The CLT self-weight is already taken into account in the table at ρ = 500 kg/m³!

Service class 1, imposed load category A (ψ_0 = 0.7; ψ_1 = 0.5; ψ_2 = 0.3)

Load-bearing capacity:
a) Verification of bending stresses
b) Verification of shearing stresses

kmod = 0.8

Serviceability:
a) Quasi-constant design situation
zul w fin = 250
b) Infrequent design situation:
zul w q,inst = 300
zul w fin - w g,inst = 200

kdef = 0.6

Fire resistance
HFA 2011
v1 = 0.65 mm/min

R0
R30
R60
R90

This table specifies the required thicknesses for the normal design situation (R0). The colour shading represents the fire resistance time which is also attained with this thickness. If a higher fire resistance time is required, a separate analysis must be carried out.
This table is only for preliminary estimate purposes and is not a substitute for a structural analysis.

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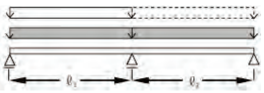
Structural analysis

TWO-SPAN BEAM - VIBRATION 04/2012



Two-span beam_Vibration

In accordance with approval Z 9.1-559
DIN 1052 (2008) and/or EN 1995-1-1 (2006)

Dead weight	Imposed load	Span of single-span beam								
gk*)	nk	3,00 m	3,50 m	4,00 m	4,50 m	5,00 m	5,50 m	6,00 m	6,50 m	7,00 m
1,00	1,00	60 L3s	80 L3s	80 L3s	100 L3s	120 L3s	140 L5s	160 L5s – 2	180 L5s	220 L7s – 2
	2,00	80 L3s	90 L3s	90 L3s	120 L3s	120 L3s	160 L5s – 2		200 L5s	
	2,80		80 L3s			140 L5s		180 L5s	220 L7s – 2	
	3,50	80 L3s		100 L3s	120 L3s					240 L7s – 2
	4,00		90 L3s					200 L5s		
	5,00		100 L3s	120 L3s						
1,50	1,00	80 L3s	80 L3s	90 L3s	120 L3s	140 L5s	160 L5s – 2	180 L5s	220 L7s – 2	220 L7s – 2
	2,00	80 L3s						200 L5s		240 L7s – 2
	2,80			100 L3s	120 L3s					
	3,50			100 L3s						
	4,00		90 L3s	120 L3s		160 L5s – 2	180 L5s			
	5,00		100 L3s		140 L5s			220 L7s – 2		
2,00	1,00	80 L3s	80 L3s	100 L3s	120 L3s	140 L5s	160 L5s – 2	200 L5s	220 L7s – 2	240 L7s – 2
	2,00				120 L3s					
	2,80		80 L3s	120 L3s	140 L5s	160 L5s – 2	180 L5s	220 L7s – 2		
	3,50		90 L3s	120 L3s						
	4,00									
	5,00		100 L3s				200 L5s		240 L7s – 2	260 L7s – 2
2,50	1,00	80 L3s	80 L3s	120 L3s	140 L5s	160 L5s – 2	180 L5s	220 L7s – 2	220 L7s – 2	240 L7s – 2
	2,00		90 L3s	120 L3s						
	2,80		90 L3s				200 L5s		240 L7s – 2	260 L7s – 2
	3,50									
	4,00									
	5,00	80 L3s	100 L3s							
3,00	1,00	80 L3s	90 L3s	120 L3s	140 L5s	160 L5s – 2	200 L5s	220 L7s – 2	240 L7s – 2	240 L7s – 2
	2,00		90 L3s							260 L7s – 2
	2,80		100 L3s							
	3,50	80 L3s								
	4,00					180 L5s				280 L7s – 2
	5,00				160 L5s – 2		220 L7s – 2			

* The CLT self-weight is already taken into account in the table at ρ = 500 kg/m³!

Service class 1, imposed load category A ($\psi_0 = 0.7$; $\psi_1 = 0.5$; $\psi_2 = 0.3$)

Load-bearing capacity:
a) Verification of bending stresses
b) Verification of shearing stresses

kmod = 0.8

Serviceability:
a) Quasi-constant design situation
zul w fin = 250
b) Infrequent design situation:
zul w q,inst = 300
zul w fin - w g,inst = 200
c) Vibration
Vibration according to EN 1995-1-1 and Kreuzinger & Mohr
($f_1 > 8$ Hz or $f_1 > 5$ Hz with a = 0.4m/s², $v < v_{grenz}$, $w_{EF} < 1$ mm)
D = 2%, 5 cm cement screed, b = 1.2 · ℓ

kdef = 0.6

Fire resistance
β = 0.65 mm/min

R0
R30
R60
R90

Since any vibration depends not only on the span but also on the mass, a thicker ceiling may be necessary despite a shorter span. The analysis was carried out using the imposed load on one field. In the event of imposed loads on both fields, the required ceiling thickness may be reduced.

This table specifies the required thicknesses for the normal design situation (R0). The colour shading represents the fire resistance time which is also attained with this thickness. If a higher fire resistance time is required, a separate analysis must be carried out.

This table is only for preliminary estimate purposes and is not a substitute for a structural analysis.

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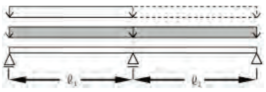
Structural analysis

TWO-SPAN BEAM - DEFORMATION 04/2012



Two-span beam_Deformation

In accordance with approval Z 9.1-559
DIN 1052 (2008) and/or EN 1995-1-1 (2006)

Dead weight gk*)	Imposed load nk	Span of single-span beam 3,00 m	3,50 m	4,00 m	4,50 m	5,00 m	5,50 m	6,00 m	6,50 m	7,00 m
1,00	1,00	60 L3s	80 L3s	80 L3s	80 L3s	90 L3s	120 L3s	120 L3s	140 L5s	140 L5s
	2,00		80 L3s		90 L3s	100 L3s	120 L3s			160 L5s – 2
	2,80	80 L3s		90 L3s	100 L3s	120 L3s		140 L5s		160 L5s – 2
	3,50	80 L3s		100 L3s	120 L3s		140 L5s		160 L5s – 2	
	4,00		90 L3s					160 L5s – 2		180 L5s
	5,00		100 L3s	120 L3s		140 L5s	160 L5s – 2	160 L5s – 2	180 L5s	200 L5s
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	5,00		100 L3s	120 L3s		140 L5s	160 L5s – 2		180 L5s	200 L5s
2,00	1,00	80 L3s	80 L3s	90 L3s	100 L3s	120 L3s	120 L3s	140 L5s	160 L5s – 2	160 L5s – 2
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	3,50							160 L5s – 2		
	4,00		90 L3s							
	5,00		100 L3s	120 L3s		140 L5s	160 L5s – 2		180 L5s	200 L5s
2,50	1,00	80 L3s	80 L3s	90 L3s	120 L3s	120 L3s	140 L5s	140 L5s	160 L5s – 2	160 L5s – 2
	2,00		80 L3s	100 L3s				160 L5s – 2		180 L5s
	2,80		90 L3s							
	3,50					140 L5s				200 L5s
	4,00			120 L3s					180 L5s	
	5,00	80 L3s	100 L3s				160 L5s – 2			
3,00	1,00	80 L3s	80 L3s	100 L3s	120 L3s	120 L3s	140 L5s	160 L5s – 2	160 L5s – 2	180 L5s
	2,00		90 L3s			140 L5s				200 L5s
	2,80			120 L3s					180 L5s	
	3,50	80 L3s					160 L5s – 2			
	4,00									
	5,00		100 L3s						200 L5s	220 L7s – 2

* The CLT self-weight is already taken into account in the table at ρ = 500 kg/m³!

Service class 1, imposed load category A (ψ0 = 0.7; ψ1 = 0.5; ψ2 = 0.3)

Load-bearing capacity:
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kdef = 0.6

Fire resistance
HFA 2011
v1 = 0.65 mm/min

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R90

The analysis was carried out using the imposed load on one field. In the event of imposed loads on both fields, the required ceiling thickness may be reduced.

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Structural analysis

APPLICATION EXAMPLE - CEILING 04/**2012**

1.) Assumption regarding dead weight

- The **dead weight** of the ceiling structure (screed, etc.) is assumed, for example, to be g_k = 1.5 kN/m²; the dead weight of the CLT panel has already been taken into account in the table.

2.) Assumption regarding imposed load

- Living space 2.00 kN/m² + partition wall allowance 0.8 kN/m² → n_k = 2.8 kN/m²

(Different imposed loads must be inserted, depending on the type of use, e.g. meeting room, office, pitched roof area, etc.)

3.) Determining span

- There are two options: single-span beam and two-span beam → single-span beam with 4.5 m is used in this case.

4.) Defining criterion for evidence of serviceability

- There are two different criteria: evidence of deformation (see separate dimensioning table) and evidence of vibration properties → evidence of vibration properties is decisive in this case.

5.) Using a preliminary estimate table

- A CLT 120 L3s is proposed; this meets the R 30 specifications at the same time.

Single-span beam_Vibration

In accordance with approval Z 9.1-559
DIN 1052 (2008) and/or EN 1995-1-1 (2006)

Dead weight gk*)	Imposed load nk	Span of single-span beam								
		3,00 m	3,50 m	4,00 m	4,50 m	5,00 m	5,50 m	6,00 m	6,50 m	7,00 m
1,00	1,00		80 L3s	90 L3s		120 L3s	140 L5s	160 L5s – 2	180 L5s	
	2,00	80 L3s	90 L3s	100 L3s	120 L3s	120 L3s			200 L5s	220 L7s – 2
	2,80							180 L5s		
	3,50	80 L3s	90 L3s	120 L3s	120 L3s	140 L5s	160 L5s – 2			
	4,00		100 L3s		140 L5s			200 L5s	220 L7s – 2	240 L7s – 2
	5,00	90 L3s	120 L3s	120 L3s		160 L5s – 2				
1,50	1,00	80 L3s	90 L3s	100 L3s	120 L3s			180 L5s	200 L5s	220 L7s – 2
	2,00					140 L5s				
	2,80	80 L3s		120 L3s	120 L3s		160 L5s – 2			
	3,50		100 L3s					200 L5s	220 L7s – 2	240 L7s – 2
	4,00	90 L3s		120 L3s	140 L5s	160 L5s – 2				
	5,00	90 L3s	120 L3s				180 L5s	220 L7s – 2		
2,00	1,00	80 L3s			120 L3s	140 L5s	160 L5s – 2			
	2,00		100 L3s	120 L3s				200 L5s		
	2,80	90 L3s							220 L7s – 2	240 L7s – 2
	3,50				140 L5s	160 L5s – 2	180 L5s			
	4,00	90 L3s	120 L3s	120 L3s				220 L7s – 2		
	5,00						200 L5s		240 L7s – 2	260 L7s – 2
2,50	1,00	90 L3s	100 L3s	120 L3s			160 L5s – 2	200 L5s		
	2,00						180 L5s		220 L7s – 2	240 L7s – 2
	2,80		120 L3s	120 L3s	140 L5s	160 L5s – 2				
	3,50	90 L3s						220 L7s – 2		
	4,00			140 L5s			200 L5s		240 L7s – 2	260 L7s – 2
	5,00	100 L3s	120 L3s		160 L5s – 2					
3,00	1,00	90 L3s		120 L3s	140 L5s		180 L5s		220 L7s – 2	240 L7s – 2
	2,00	90 L3s	120 L3s							
	2,80					160 L5s – 2		220 L7s – 2		260 L7s – 2
	3,50	100 L3s		140 L5s	160 L5s – 2		200 L5s		240 L7s – 2	
	4,00		120 L3s							
	5,00					180 L5s				280 L7s – 2

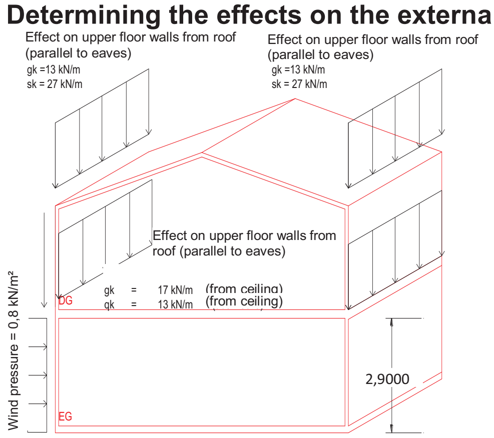
* The CLT self-weight is already taken into account in the table at ρ = 500 kg/m³!

Service class 1, imposed load category A (ψ_0 = 0.7; ψ_1 = 0.5; ψ_2 = 0.3)

R0
R30
R60
R90

Structural analysis

1.) Determining the effects on the external wall



Effect on ground floor walls (lengthwise along the eaves)

g_k = 13 kN/m (from roof) + 17 kN/m (from ceiling) = 30 kN/m
s_k = 27 kN/m (from roof)
q_k = 13 kN/m (from ceiling) $s_k + q_k$ = 40 kN/m
w_k = 0.8 kN/mi (from wind pressure)

- This requires information about the building location (altitude, snow zone, wind zone, etc.)
- Since the outer wall usually bears the weight of the roof, information is required about the roof structure.
- Determination of the characteristic values is sufficent to use the tables. The design values are automatically taken into account in the tables.

2.) Determining the buckling length of the wall

- In this case the buckling length corresponds to the wall height = 2.90 m ~ 3.00 m

3.) Determining criteria for the fire load

- "Fire-retardant" = R 30

4.) Using a preliminary estimate table

- A CLT 90 C3s is proposed

External walls (w = 1.00 kN/m²)

In accordance w ith approval Z 9.1-559
DIN 1052 (2008) and/or EN 1995-1-1 (2006)

Dead weight gk*)	Imposed load nk	Height (buckling length)											
		2,50 m				3,00 m				4,00 m			
		R 0	R 30	R 60	R 90	R 0	R 30	R 60	R 90	R 0	R 30	R 60	R 90
10,00	10,00			80 C3s						60 C3s	80 C3s	100 C5s	120 C3s
	20,00					60 C3s			120 C3s				
	30,00	60 C3s	80 C3s		120 C3s		80 C3s	100 C5s		80 C3s	90 C3s		
	40,00			100 C5s							100 C3s	120 C5s	140 C5s
	50,00					80 C3s			140 C5s				
	60,00	80 C3s					90 C3s			90 C3s	100 C5s		
20,00	10,00			80 C3s		60 C3s			120 C3s		80 C3s	100 C5s	
	20,00	60 C3s					80 C3s			80 C3s	90 C3s		
	30,00		80 C3s		120 C3s			100 C5s			100 C3s		140 C5s
	40,00			100 C5s		80 C3s			140 C5s			120 C5s	
	50,00	80 C3s					90 C3s			90 C3s	100 C5s		
	60,00				140 C5s			120 C5s					
30,00	10,00					60 C3s			120 C3s		90 C3s		
	20,00	60 C3s			120 C3s		80 C3s	100 C5s		80 C3s	100 C3s		
	30,00		80 C3s	100 C5s								120 C5s	140 C5s
	40,00					80 C3s			140 C5s				
	50,00	80 C3s			140 C5s		90 C3s	120 C5s		90 C3s	100 C5s		
	60,00												
40,00	10,00					60 C3s	80 C3s		120 C3s	80 C3s	90 C3s		
	20,00	60 C3s			120 C3s			100 C5s			100 C3s		
	30,00		80 C3s	100 C5s								120 C5s	140 C5s
	40,00					80 C3s	90 C3s		140 C5s	90 C3s	100 C5s		
	50,00	80 C3s			140 C5s			120 C5s					
	60,00		90 C3s				100 C3s			100 C3s	120 C3s		
50,00	10,00	60 C3s			120 C3s		80 C3s	100 C5s		80 C3s	100 C3s		
	20,00		80 C3s										
	30,00			100 C5s		80 C3s	90 C3s		140 C5s	90 C3s	100 C5s	120 C5s	140 C5s
	40,00	80 C3s			140 C5s			120 C5s					
	50,00		90 C3s				100 C3s			100 C3s	120 C3s		
	60,00			120 C5s									
60,00	10,00	60 C3s			120 C3s			100 C5s			100 C3s		
	20,00		80 C3s	100 C5s			90 C3s			90 C3s	100 C5s		
	30,00					80 C3s			140 C5s			120 C5s	140 C5s
	40,00	80 C3s			140 C5s			120 C5s					
	50,00		90 C3s	120 C5s			100 C3s			100 C3s	120 C3s		
	60,00												160 C5s

* The CLT self-weight is already taken into account in the table at ρ = 500 kg/m³!

Service class 1, imposed load category A (ψ_0 = 0.7; ψ_1 = 0.5; ψ_2 = 0.3)

R0
R30
R60
R90

Structural analysis

Thanks to their high static strength and flexibility, buildings built with CLT solid wood panels perform superbly in areas of seismic activity. As solid wood is lighter than concrete, the weight of the building is better able to withstand tremors.

In recent years, six- and seven-storey solid wood buildings were tested on the world's largest vibrating table in Japan during simulations of earthquakes measuring 7.5 on the open-ended Richter scale. The buildings suffered virtually no damage.

(See also: http://www.progettosofie.it/ita/multimedia.html)

"Earthquake performance of buildings of solid wood construction"

At the request of Stora Enso, Graz University of Technology composed a 214-page work comparing CLT, tile and concrete in terms of earthquake performance. The work also clearly demonstrates how to perform a structural analysis (according to Eurocode 8) with regard to earthquakes.

The information brochure can be downloaded from **www.clt.info**.

"Evidence of the earthquake safety of wooden buildings"

In addition, Stora Enso recommends the extremely informative study on the earthquake safety of wooden buildings written by the Chamber of Engineers in North Rhine Westphalia and Düsseldorf. (See: ***www.ikbaunrw.de)***

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