Building physics

Contents:

1.	Introduction
2.	Relevance of airtightness/windtightness
3.	Benefits of CLT with regard to airtightness
4.	Technical aspects of airtightness
5.	Configurations and specific connections
6.	Summary
7.	Appendix

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 special single-layer panel design results in an airtight layer which means that an additional airtight membrane is not generally required on the inside of the room. 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

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].

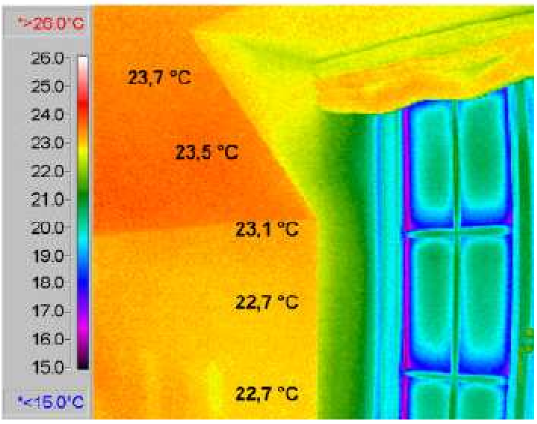
b) Windtightness:

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]).

Windstille



7 m/s Windgeschwindigkeit

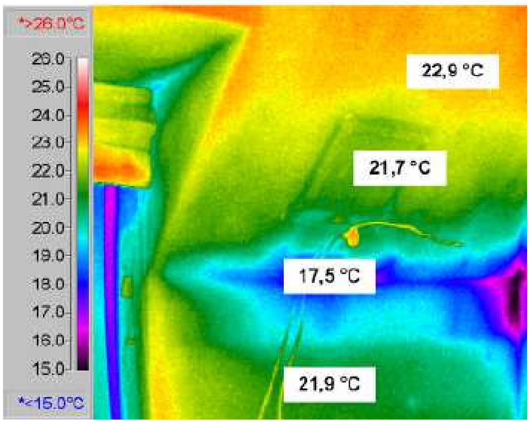


Illustration: Thermographic images of a wall/roof connection at + 3℃ outdoor temperature and + 24℃ indoor temperature (taken fr om [1])

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 (μ) 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].

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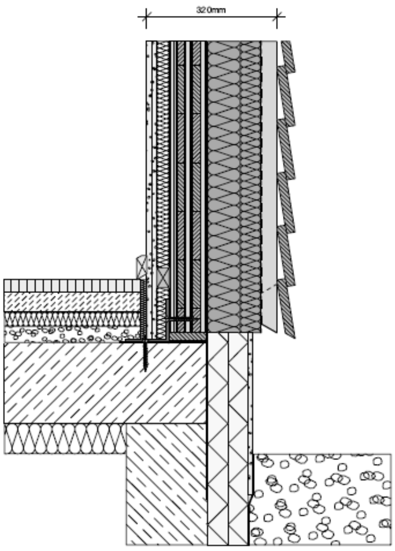
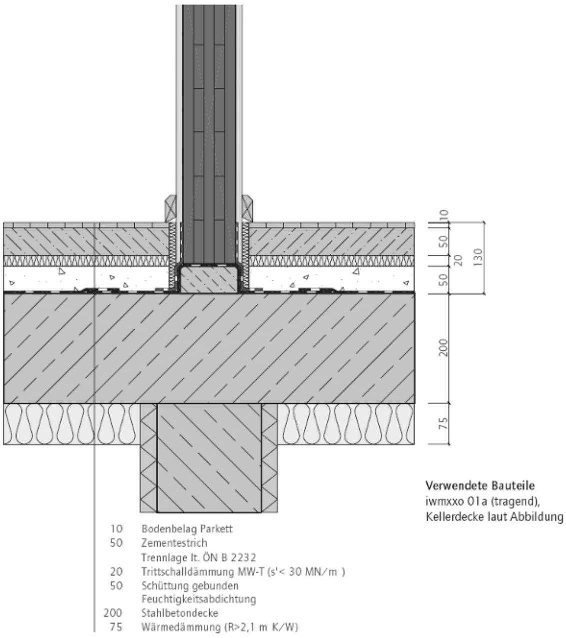
a) Plinth connection I



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.

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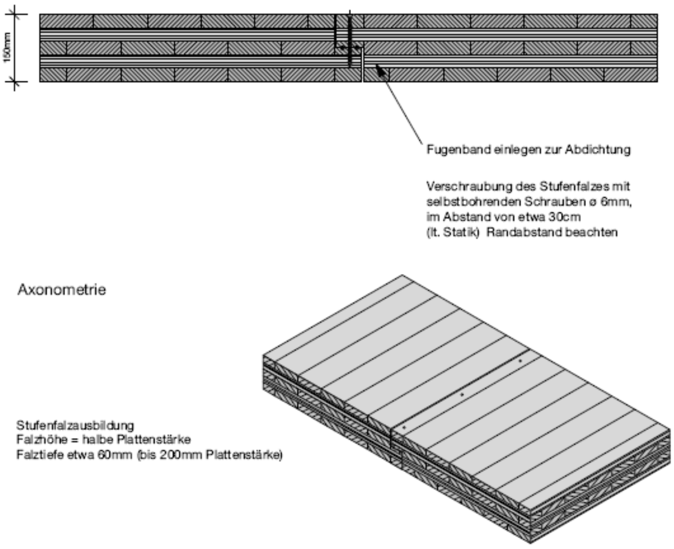
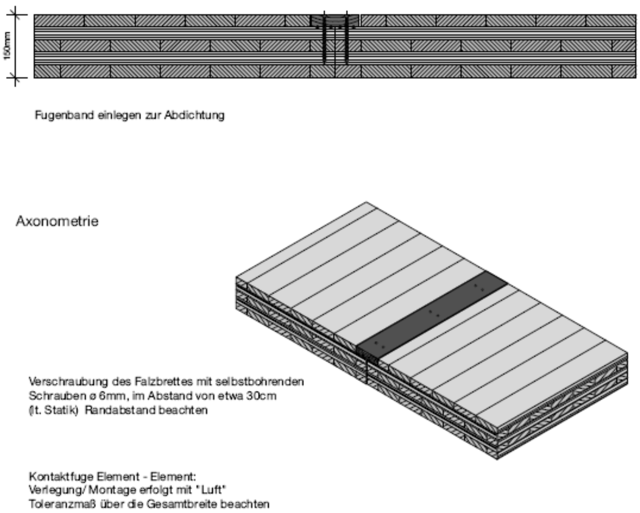
b) Wall and ceiling joint I



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).

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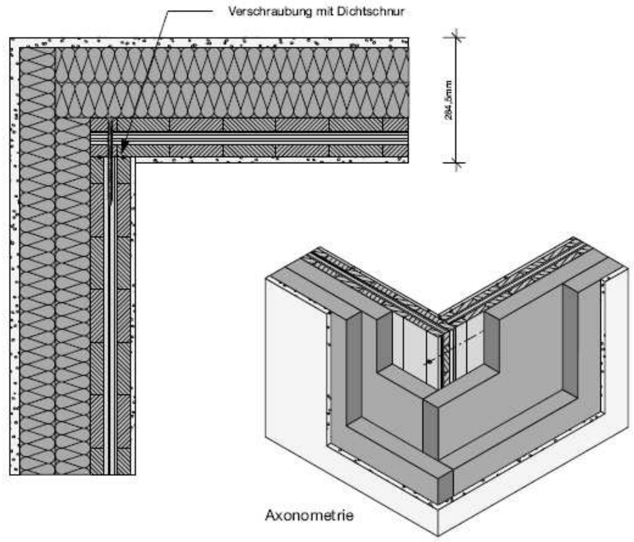
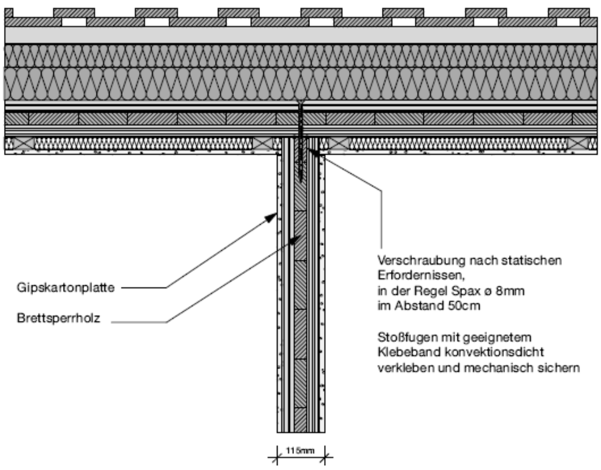
c) Wall connection I



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.

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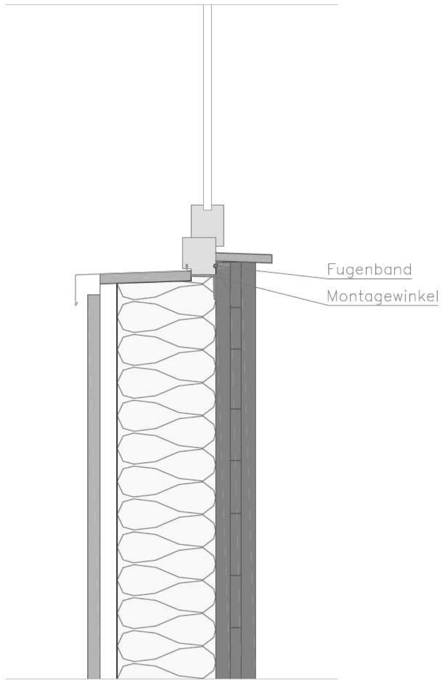
d) Window or door connection I

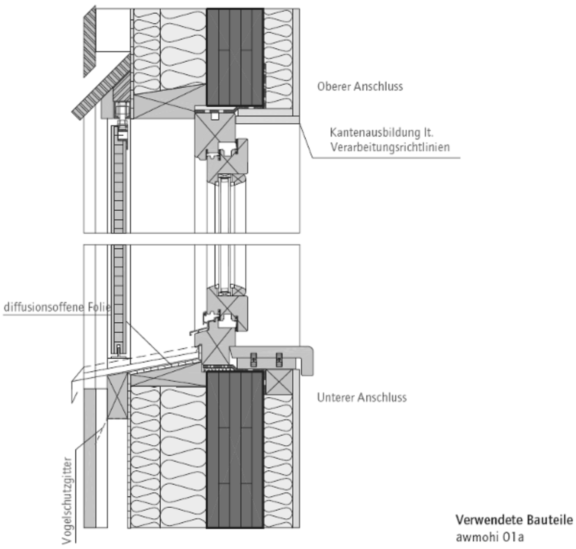


Connection of fitted window:

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 "Comprib-and", 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.).

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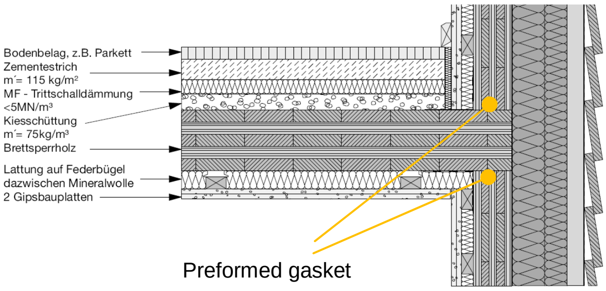
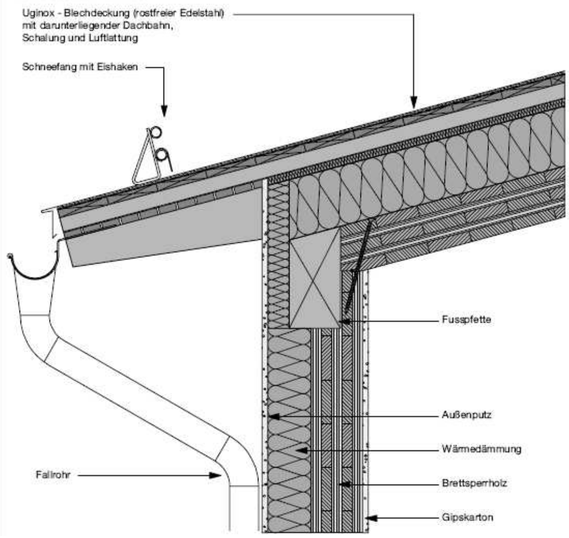
e) Wall/ceiling/wall connection



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.

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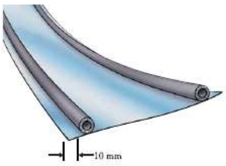
g) A few examples of materials for creating an airtight finish



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

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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

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