# Building Systems by Stora Enso

## Residential multi-storey buildings

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# 1 Introduction and disclaimer

# 1.1 Introduction

This manual defines the Stora Enso solid wood panel and rib slab system for wooden multi-storey residential buildings. It is intended for designers, contractors, building owners and developers.

The structural solutions contained in these pages are intended for the system shown here, but they may also be applied outside the scope of the manual. The core of the system is Stora Enso's solid structural wall panels and structurally glued rib slabs, which provide both technical performance and industrial quality. These engineered wood components enable an industrial method of construction that reduces assembly time on site and eliminates the need for wet concrete construction.

The system is a generic building system that can be adjusted to various market and customer requirements depending on local needs. These adjustments might include:

Architectural considerations

- typology and scale of the building
- unit and room layouts
- customer demands or local market factors

Engineering considerations

- local performance requirements (acoustics, fire protection, thermal insulation, etc.)
- local code requirements (defined by relevant building authorities)

The manual offers a good overview of common European structures and building types but should also gives inspiration for new ideas and experiments.

Detailed design instructions and structural drawings can be downloaded from the web pages of Stora Enso Building Solutions.

## 1.2 The benefits of the system

The system offers several benefits for all parties in building process.

For architects it provides:
- systems and materials that enable high quality architecture and interiors
- open systems that allows products, structures and shapes to be easily combined
- safe solutions and proven technologies to fulfil the requirements of building authorities
- framework for the development of the building design

For engineers it provides:
- an easy, safe and dependable system of design
- proven structural details
- clearly defined performance values for structures
- a clear system and guidelines for bracing the building
- quality background material and design tools
- structural details available for download
- a manual and software for structural calculations
- third-party-tested structures and design methods

For contractors and carpenters it provides:
- safe solutions — tested and proven instructions for the whole building process
- fast assembly times
- a proven structural system
- industrial components with factory precision
- no drying or curing times
- lightweight structures that reduce or eliminate the need for heavy lifting equipment

For owners and occupants it provides:
- cost efficiency
- modern design with visible wooden interior surfaces
- healthy wooden living/building
- healthy living with natural materials
- energy efficiency — low heating and cooling costs for the whole building
- ecological benefits; low energy consumption and a lower carbon footprint

For developers it provides:
- a short construction phase — less time to wait on investment returns
- an attractive product for modern and environmentally conscious customers
- a system that can be tailored for varying types and sizes of buildings

## 1.3 Disclaimer

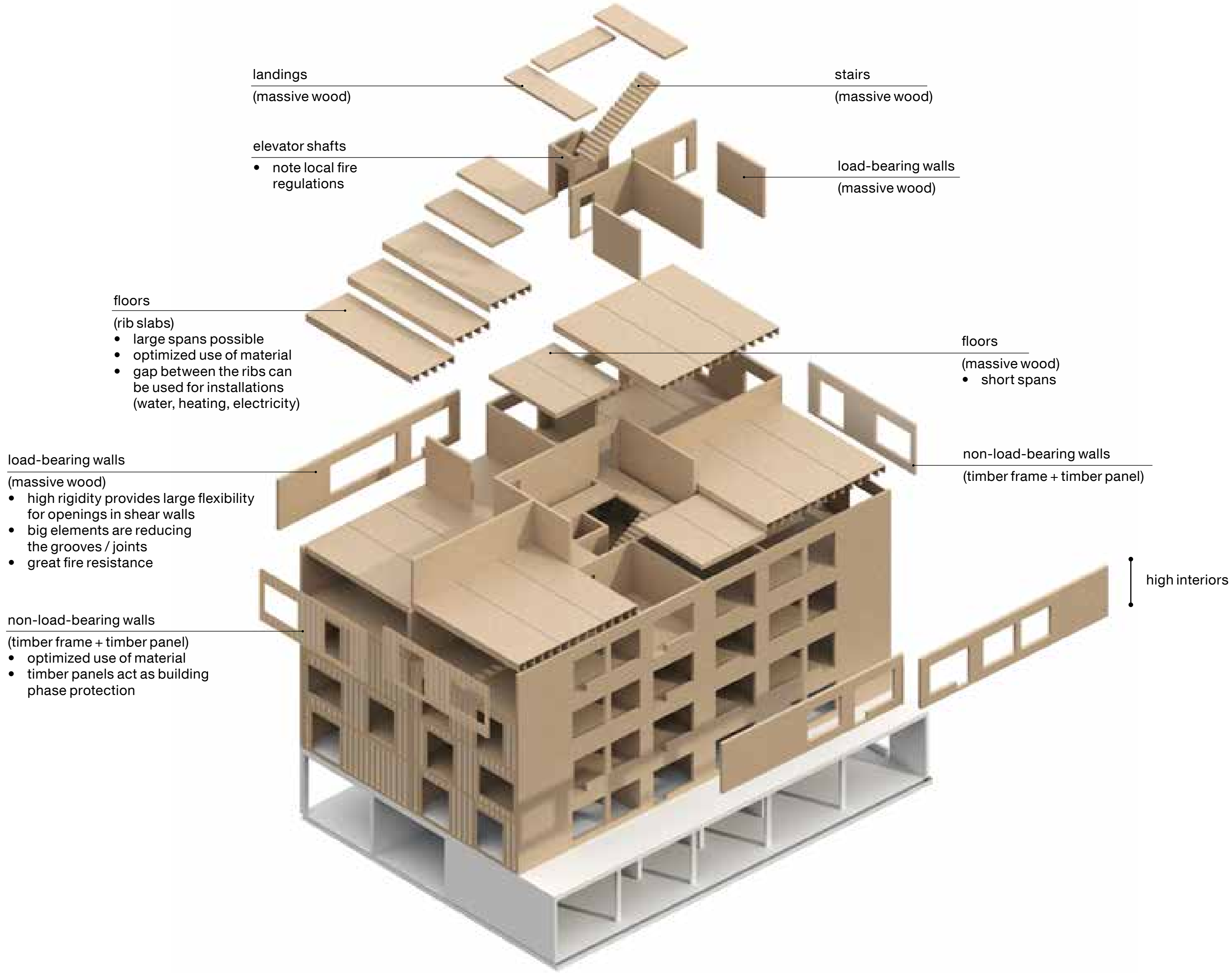
The manual is meant for preliminary design of buildings and structures.

The use of the structural solutions (and reference values) shown here does not replace the need for final design and calculations by responsible designers — including but not limited to structural, acoustic, fire or building physical design — and thus all solutions and details used in construction should be reviewed, verified and approved by the responsible designers of the project. Conformance with local building regulations shall be confirmed by the responsible designers. Design details are subject to change.

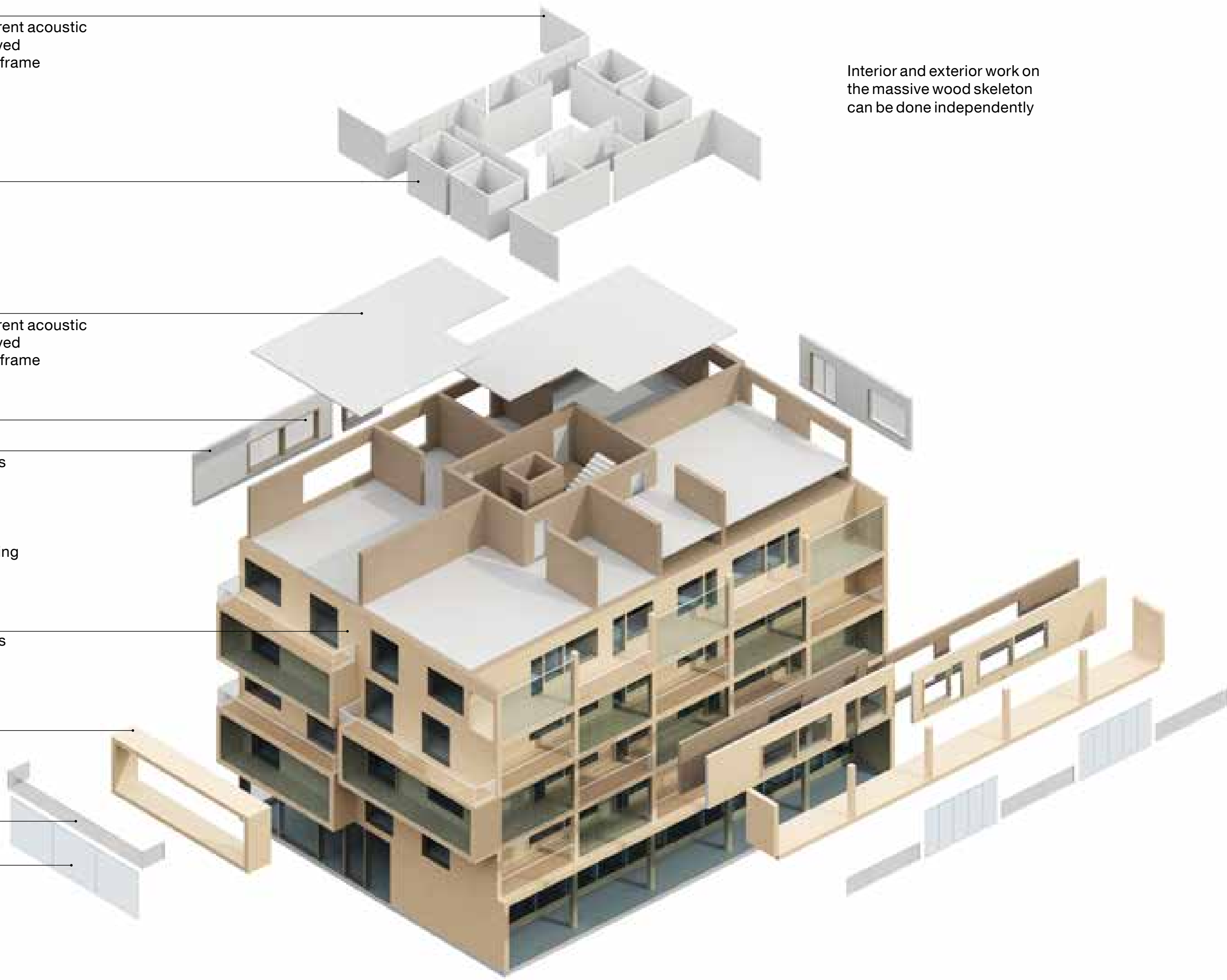
Stora Enso does not give any warranties, representations or undertakings about the accuracy, validity, timeliness or completeness of any information or data in this manual and expressly disclaims any warranties of merchant-ability or fitness for particular purpose. In no event will Stora Enso be liable for any direct, special, indirect, consequential incidental damages or any other damages of any kind cause by the use of this manual.

# 2 Anatomy of the Stora Enso Building System

# Basic components: the building frame



# Variable components: additions and alternatives



interior surfaces
(materials and finishes)
- by modifying surface layers different acoustic and fire regulations can be achieved
- separated from the load-bearing frame

non-load-bearing walls
(positions and openings)
- optimized use of material
- adjustable wall positions
- flexible space design

floors and ceilings
(interior surfaces)
- by modifying surface layers different acoustic and fire regulations can be achieved
- separated from the load-bearing frame

windows / doors

façades / insulation
- possible to use different materials
- can be elemented

clear separation between load-bearing elements and insulations

façades / exterior surfaces
- possible to use different materials
- can be elemented

balconies
- technically possible to use different balcony types

railings

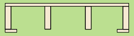
glazing

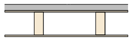
Interior and exterior work on the massive wood skeleton can be done independently

# Building components

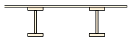
The table below shows components used in the Stora Enso model building as compared with various other multi-storey timber buildings. The components of the Stora Enso system have been chosen for optimal performance in bracing, fire protection, acoustics and deformation in order to meet the most demanding building regulations. The Stora Enso system is an open system — the system can be extended with components outside the system.

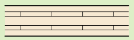
## Floors

rib slab


timber-concrete composite


timber floor joist

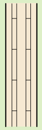

timber floor with I-joist


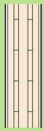
massive wood slab


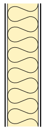
### Rib slab

- Large spans are possible due to high rigidity and low self-weight
- Optimized geometry achieve maximum performance with the least material spent
- Light — no heavy lifting equipment necessary
- No cast-in-place concrete required compared to concrete composite or precast solutions

## Fire protection

massive wood


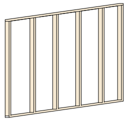
massive wood with non-combustible surface layers


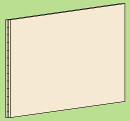
timber frame with non-combustible surface layers


### Fire protection — massive wood walls

- Well-known and predictable charring behaviour — low risk of an abrupt collapse
- Void-free construction prevents fire spread within the structure
- May burn and char from the surface – the low density char layer acts as a heat insulation for the underlaying timber
- Under the char layer and pyrolysis zone remains uncharred timber with high strength and stiffness properties for a long and predictable time
- The use of protective layers such as gypsym boards reduces the thickness of the required load-bearing structure

## Walls

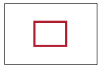
timber frame


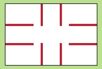
massive wood wall


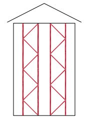
### Massive wood wall

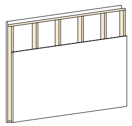
- Good fire resistance
- Efficient load distribution in a shear wall system (less concentrated load)
- Light — no heavy lifting equipment necessary
- Dimensional stability due to cross lamination — limiting creep and shrinkage
- High rigidity provides large flexibility for openings in shear walls

## Bracing

concrete core


massive wood shear walls


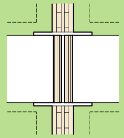
trusses


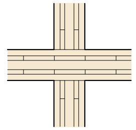
timber frame + wall panels


### Bracing — massive wood walls and rib slabs

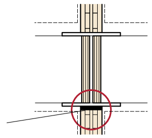
- Entire bracing system established with timber elements — no steel or concrete required
- High rigidity provides large flexibility for openings in shear walls
- Linear load distribution from floor to walls — less concentrated loads

## Joint types

hard joint + decoupled installation layers


solid joint


soft joint

soft layer


### Joints

- Joints are designed at a maximum amount of rigidity with the most adequate acoustic insulation at the same time
- Flanking sound transmission is reduced
- Vertical load path was directed through timber parts with grain orientation parallel to the force — therefore vertical deformations due to elastic contraction, creep and shrinkage are kept at a minimum

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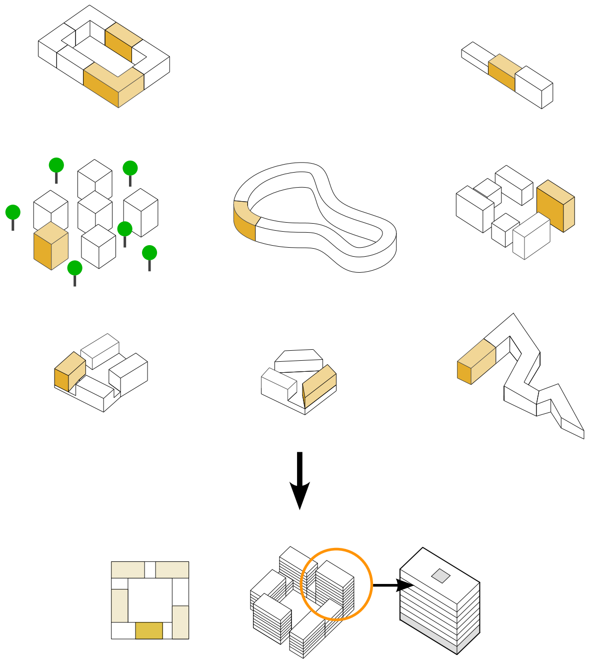
# 3 Architectural design guidelines

The following guidelines are meant to help architects apply the Stora Enso system to the particular needs of various types of multi-storey housing. These five basic principles may be applied in any order according to the particular needs of the project.

## Define the urban scale

Massing strategy and building volume

In the preliminary design phases, the urban scale and mass of the project are defined. The size of the volumes may vary from large urban blocks to smaller apartment houses. Depending on the particular site and surroundings, the architect can consider and propose varying typologies for the whole project or for specific buildings.

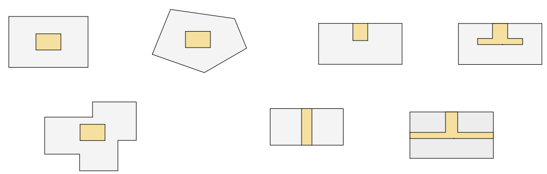


Case study example:
8-storey point access block

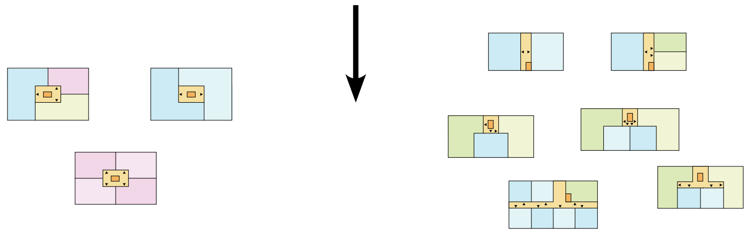
## Define the building typology

Footprint, unit distribution and vertical circulation

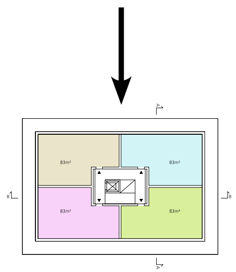
The footprint of the building as well as the distribution of living units, shape and position of the vertical access core form the basic parameters of the building structure. A symmetrical layout with a central core will optimise the load-bearing structures and shear walls, improving the economics of the project.



Variations in building footprint and location
of the vertical access core



Variations in unit types and distribution



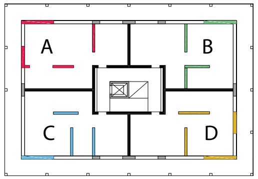
Case study example:
central core with four units per floor

# Structural principles and bearing elements

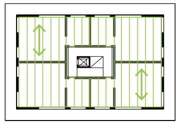
Shear walls / load-bearing walls
Ribbed slabs / load-bearing directions
Massing strategy and building volume

Core walls and walls dividing apartments are usually the most suitable for use as shear and load-bearing structures. However, even long shear wall panels may still have openings or doors depending on detailed structural calculations.

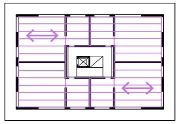
Ribbed slabs are designed to achieve long spans and usually eliminate the need for load-bearing elements inside the apartment units. The direction of the ribbed slabs defines which façades will be load-bearing. The façades which do not bear the load of the slabs will have increased flexibility for larger and more frequent openings.




load-bearing and shear walls
optional possibilities (a, b, c, d)



option 1



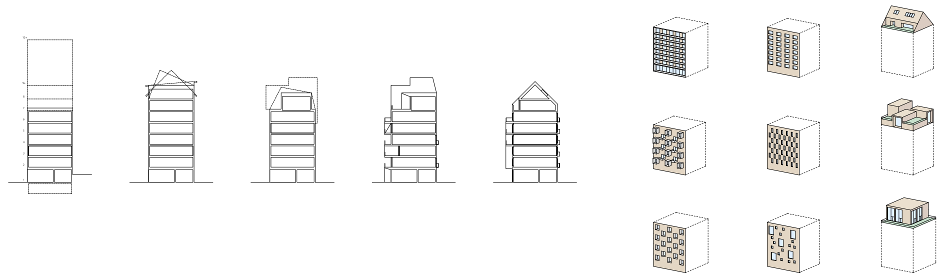
option 2

rib slab elements defining
load-bearing direction

# Additional elements

Partition walls
Doors and windows
Balconies
Fixed furniture

Non-load-bearing partition walls may be positioned freely according to the architectural layout of the units. Other elements such as balconies (recessed, cantilevered, suspended, etc.), windows (framed, glazing systems), door (hinged, sliding) and fixed furniture elements are all possible according to the architectural design.



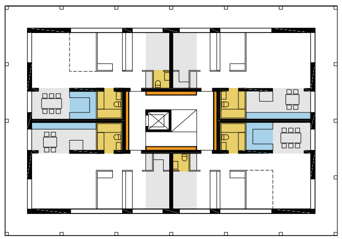
# Wet zones and technical shafts

Baths, toilets, kitchens and technical installations

In optimal layouts, technical installation shafts are located around the vertical core for easy maintenance and management.

Wet zones should also be situated next to installation shafts. Specific locations for baths, toilets and kitchens may vary inside these wet zones. Be aware that long horizontal drain lines may affect the direction and structure of slab elements.

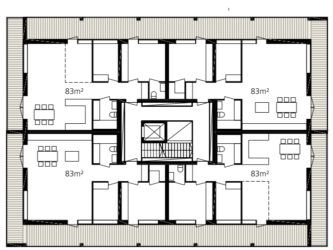
vertical shafts / installations
wet area zone / possibilities
bathroom / toilet
kitchen



# Variable elements

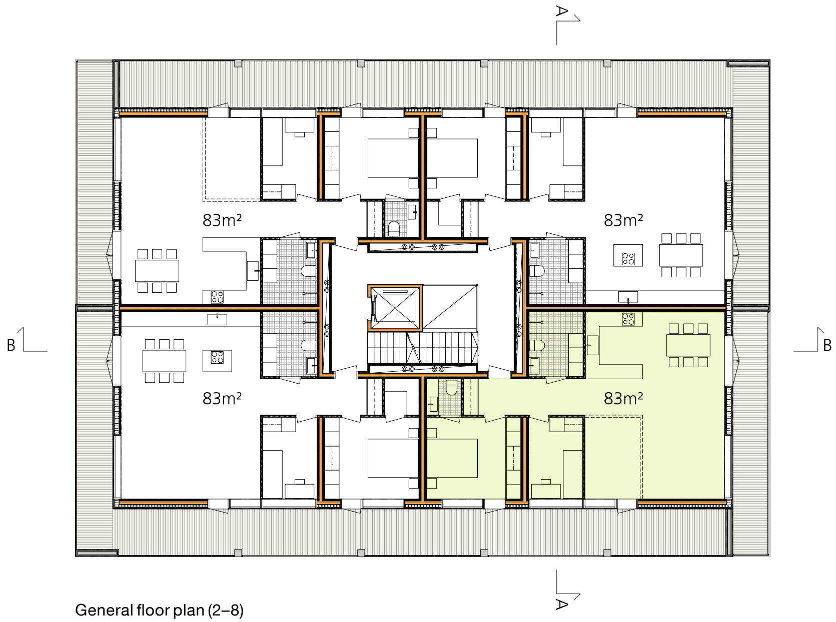
Surfaces and finishes

Surfaces and finishes for interior and exterior structures can be defined individually for each project in accordance with architectural design, technical needs and local requirements. See structural details for further information.



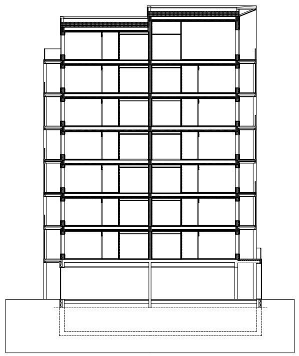
fully equipped floor plan

# Case study example:
## Central core with four units per floor

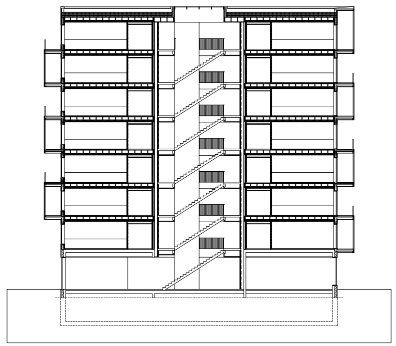



General floor plan (2–8)

Rendered elevations



Cross-section a-a



Cross-section b-b

# 4 Building System by Stora Enso

# The Building System by Stora Enso

The building process consists of three phases: manufacturing, assembly and installation of additional equipment.

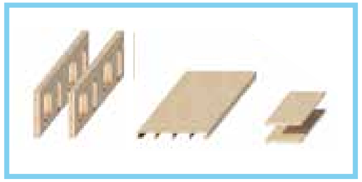
In the first phase, elements are manufactured in the factory and equipped to the extent agreed with the client.

In the second phase, the frame is assembled on site from pre-manufactured elements and protected from weather. To ensure sufficient protection, edges and openings are covered with tarpaulins or other hydrophobic membranes, eliminating any need for additional structures. In this way, the frame is exposed for as little time as possible and heating of the building interior can begin quickly to allow for phase three.

In the third phase, secondary elements such as balconies and façade elements are installed along with HVAC installations and interior finishes.

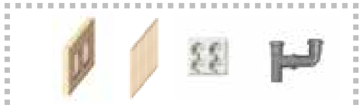
Step 1 | Timber element manufacturing

Stora Enso core parts:



Massive wood slabs

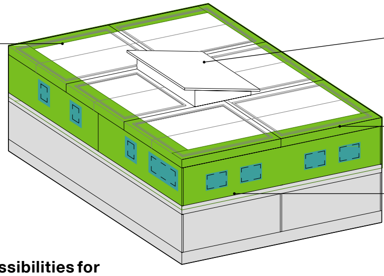
Other structural components



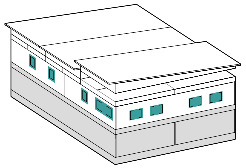
Supplements

Step 2 | Building phase “heat in, water out” weather protection with load-bearing wood components

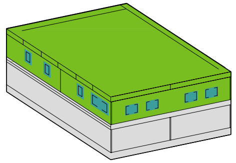
Water removal shall be planned separately.




**Possibilities for long time covering:**

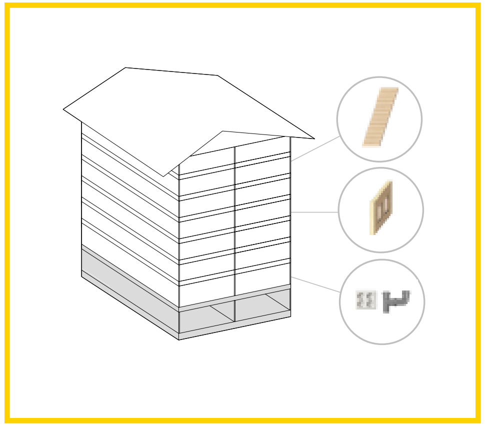


light roof elements for covering



covering with tarpaulin

Step 3 | Equipment phase of the timber frame



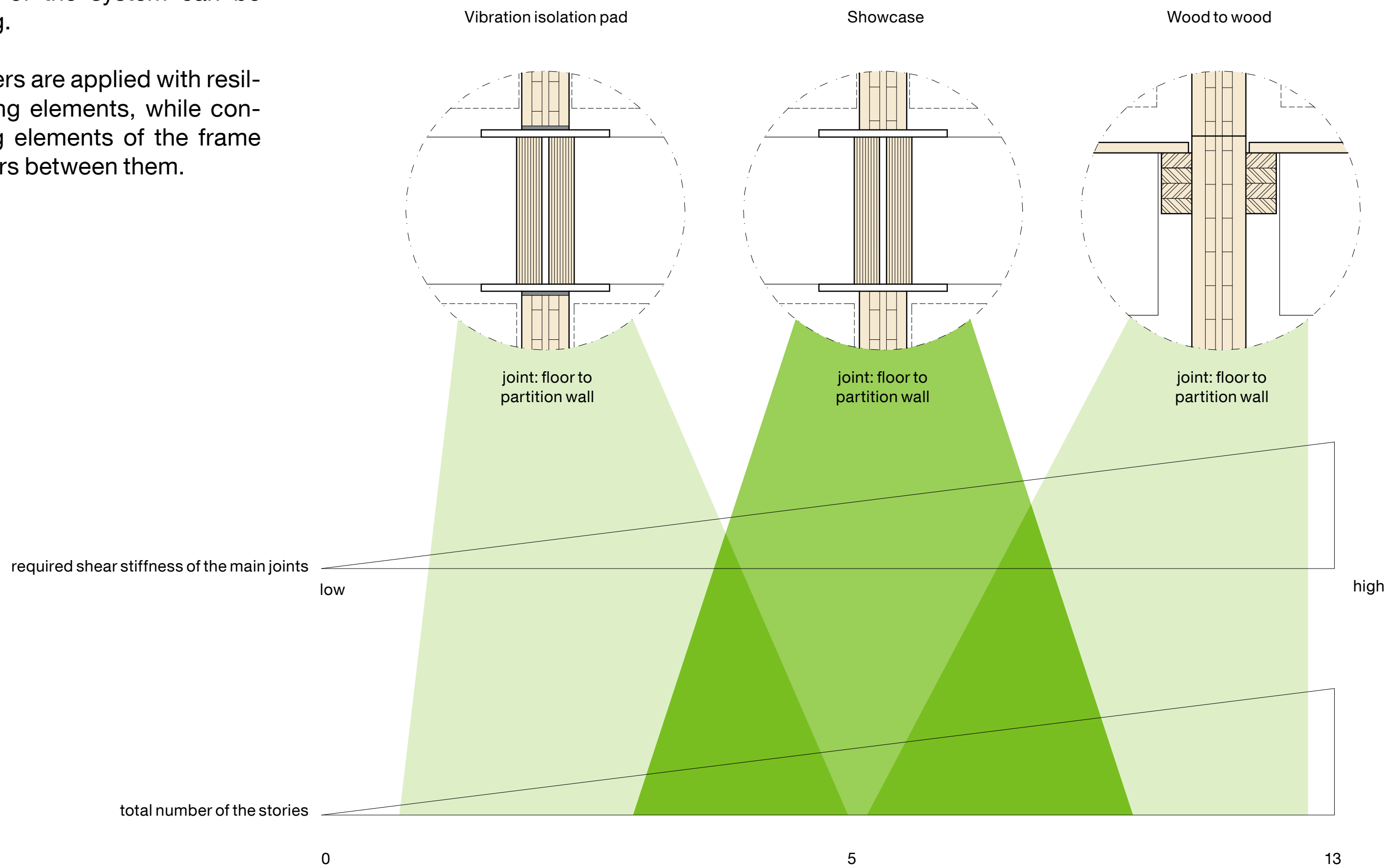
Completed building

# 4.1 Possibilities of the building system

The building system by Stora Enso is based on long span LVL rib slabs and wide CLT wall panels. Surface layers may be added to these elements depending to meet performance requirements for fire-protection or acoustic isolation.

With its variable components, the element system can be utilized for low-rise or high-rise buildings. By varying the surface structures and the stiffness of the load-bearing joints, the structural performance of the system can be adjusted to the height of the building.

In the example building, surface layers are applied with resilient connections to the load-bearing elements, while connections between the load-bearing elements of the frame are 'wood to wood' with no soft layers between them.



# Bracing

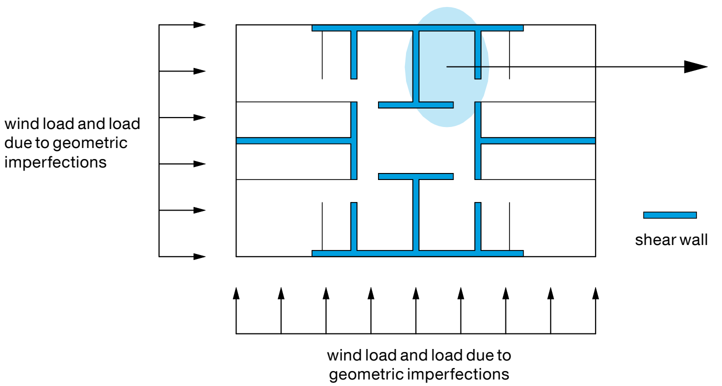
- 100% timber
- Based on floors and walls + rigid connections

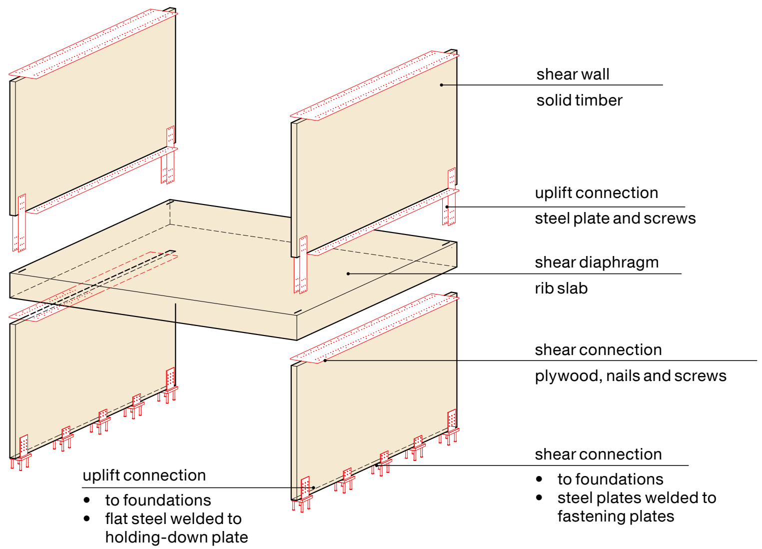
## Guidelines for multi-storey buildings

- Consult local loading conditions and building regulations
- Consider the layout and design of shear walls:
  - symmetrical floor layouts reduce torsional vibrations
  - sufficient numbers of walls insures overall stiffness
  - openings in shear elements must be carefully planned (size, location, number)

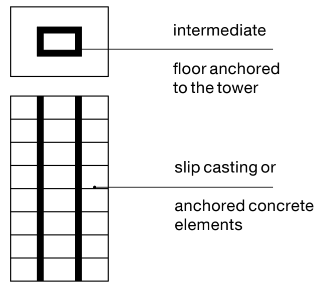
## Calculations must consider…

- Design loads
  - according to actual EN-standard
  - particularly accidential (fire and progressive collapse) and seismic
- Ultimate limit state
  - particularly loss of equilibrium
  - fracture considerations
- Service limits
  - particularly deformations and vibrations of the whole structure
  - structural members and connections
  - load-bearing capacity and stiffness



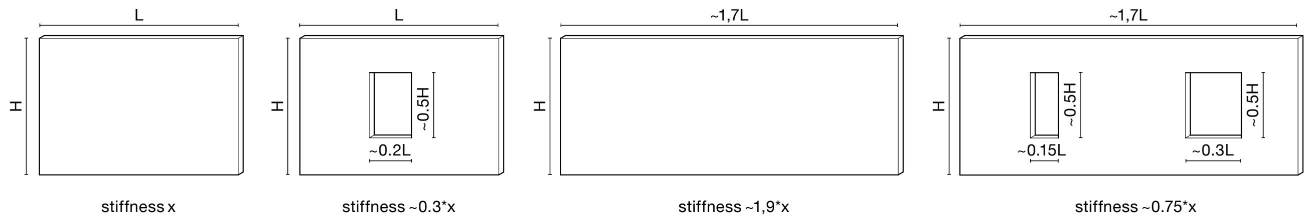




Bracing when local authorities demand or shear walls are not sufficient to stabilize the system




Bracing with concrete core

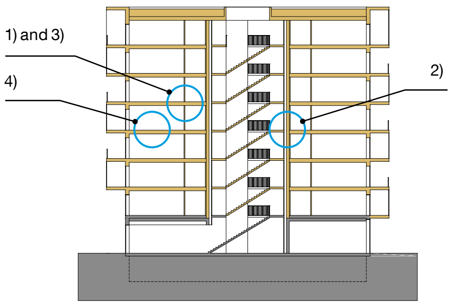
Example stiffness of CLT shear wall with openings
(note: rough estimation, size and shape shall be analysed for each case separately)



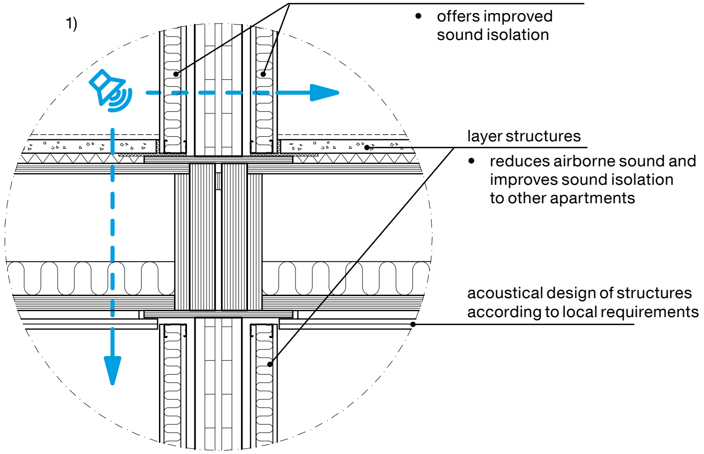
# 4.2 Principles of building acoustics

In order to control unwanted noise and vibrations, acoustic design covers a wide range of factors from the vibration of the building frame to connection details that affect flanking transmission between rooms and apartments.

The example building is designed to address four main acoustic challenges: airborne sound, impact sound, flanking transmission and plumbing noise. For more information see additional literature and contact local authorities to determine specific requirements for your project. Acoustic values given in this manual are based on calculation and used assumptions.

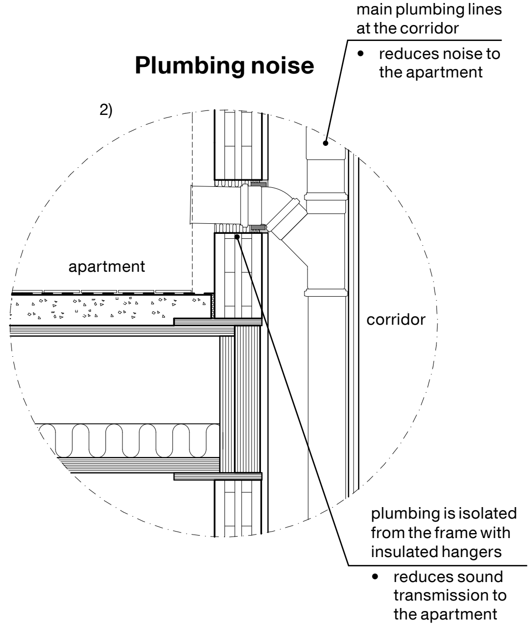



## Airborne sound

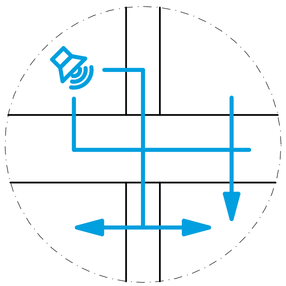



sound direct path
(the energy of the sound wave is lower due to the layer structure)

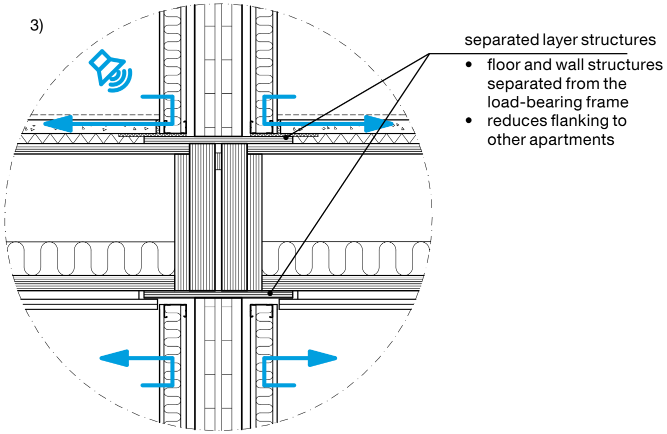
## Plumbing noise




## Flanking

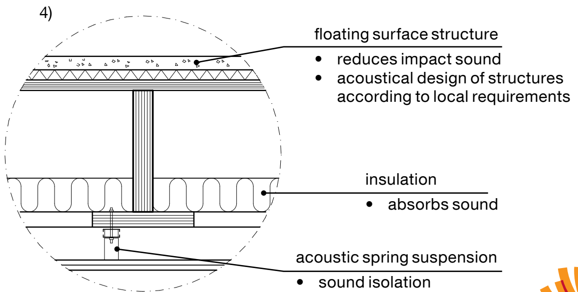


**Sound flanking path**
when direct contact to the load-bearing frame




**Sound flanking path**
when indirect contact to the load-bearing frame

## Impact sound insulation




rethink.
storaenso

# 4.3 Principles of fire design

Requirements on fire safety vary and depend on e.g. geographical location, type and use of a building. However, all local requirements must be considered. Background of fire safety-related requirements are the following main principles being regulated on European level:

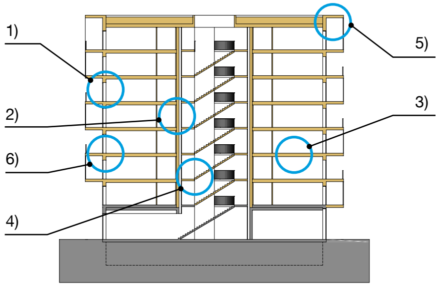
- occupants shall be able to leave the buildings or be rescued
- the safety of rescue teams shall be taken into account
- load-bearing structures shall resist fire for the required minimum duration of time
- the generation and spread of fire and smoke shall be limited
- the spread of fire to neighbouring buildings shall be limited

Out of these main principles, following requirements on building components do exist:

- reaction to fire
  - describes the contribution of building materials to fire
  - verification with classification according to EN 13501-1
- fire resistance
  - describes the resistance of building components in case of fire
  - verification with classification according to EN 13501-2 or calculation according to EN 1995-1-2

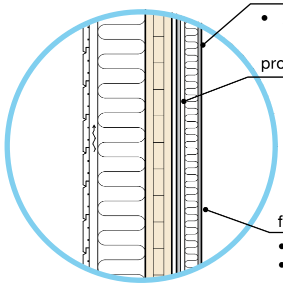
Principles concerning how to provide fire resistance with layups based on massive wood:

- Principle 1: “Exposed massive wood”
  - no additional protection layers on massive wood; full fire resistance provided by massive wood
- Principle 2: “Limited encapsulation”
  - massive wood with fire-protective layers on it; massive wood is allowed to char
- Principle 3: “Complete encapsulation”
  - massive wood with fire-protective layers on it; massive wood is not allowed to char
- see literature and local authorities for more information
- www.clt.info

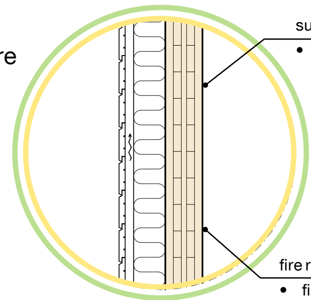



## Fire safety of the load-bearing structures

1) **Solid wall protected with surface layers**



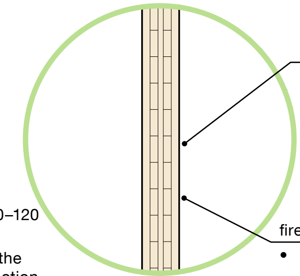

1) **Solid wall**



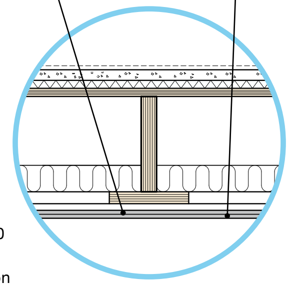

## Example of fire safety detailing

Note national rules

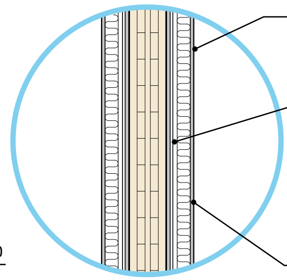
2) **Solid wall**



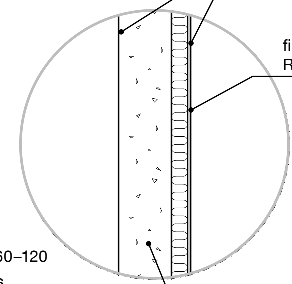

3) **Multi-layer floor structure**




2) **Solid wall protected with surface layers**

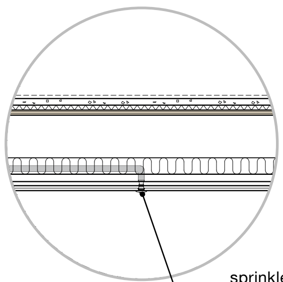



4) **Elevator shaft**

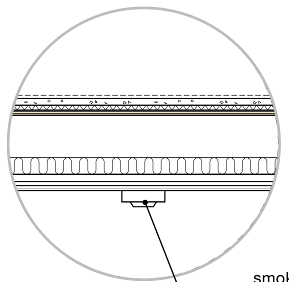



## Extinguishing and rescue

4) **Sprinkler**

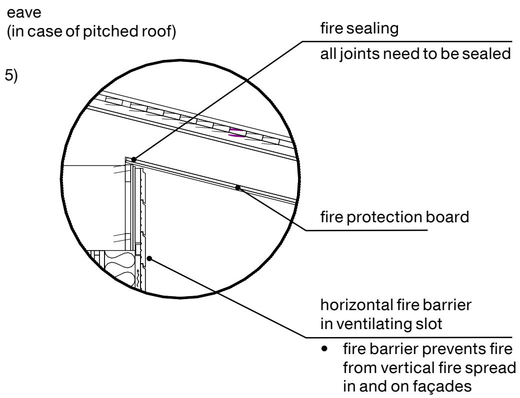


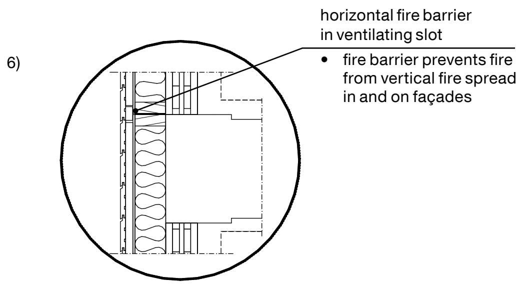

4) **Smoke detector**



# Example of fire safety detailing

Note national rules




## Fire resistance of load-bearing walls

Reference walls calculated in this manual

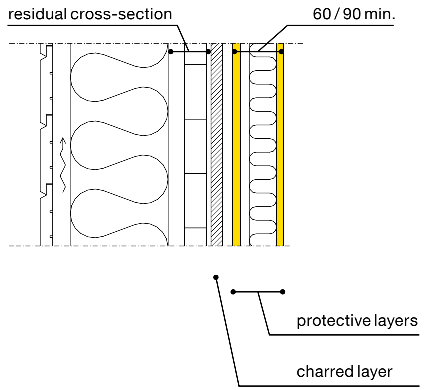
- 4 or 7 timber stories above the concrete structures (load from 3 or 6 stories and roof)
- span of floor: 8 m

Note: This calculation is just indicative and it cannot be used as fire safety design.

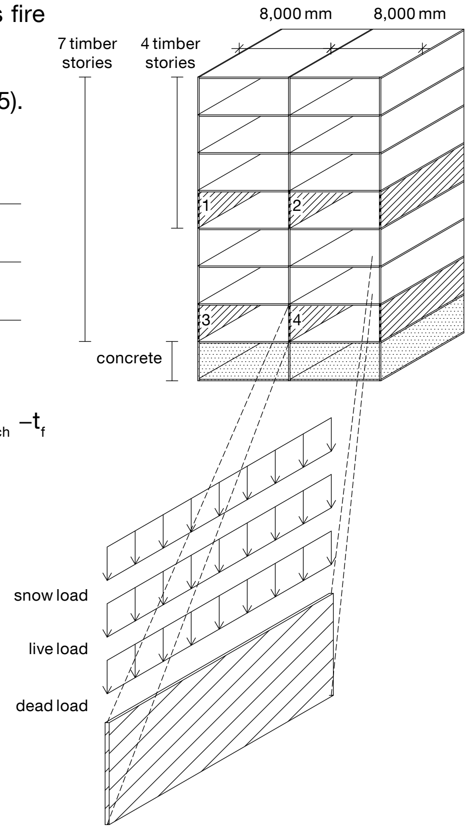
1. Define load in fire design (according EN 1990, EN 1991, EN 1995).

| | 4 stories | | 7 stories | |
|---|---|---|---|---|
| Wall number | 1 | 2 | 3 | 4 |
| Total design load (kN/m) | 117 | 217 | 194 | 357 |

2. Define the fire resistance of protective layers.
3. Define charring depth: required duration of fire resistance $-t_{ch}$ $-t_{f}$ (protective layers).




4. Check load-bearing capacity of the residual cross-section with respect to loads defined in (1).



# 4.4 Principles of controlling deformations and cracking

Deformations derive from the material properties of timber elements and properties of the structural system. Principles for timber design should consider these material behaviours to avoid excessive deformation due to cracking or creep.

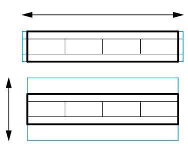
Swelling and shrinkage of wood
Dimensional changes are caused by moisture deformation, creeping and compression.

CLT
- in the panel layer: 0.02% change in length for each 1% change in timber moisture content
- perpendicular to the panel layer: 0.24% change in length for each 1% change in timber moisture content

LVL type X
- width: 0.03% change in length for each 1% change in timber moisture content
- thickness: 0.24% change in length for each 1% change in timber moisture content
- length: 0.01% change in length for each 1% change in timber moisture content

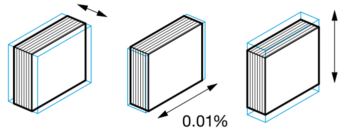
Plywood
- thickness: 0.3% change in length for each 1% change in timber moisture content

Moisture content
- manufacture moisture of CLT is 10–14%
- manufacture moisture of LVL is 8–10%
- air humidity changes between ~RH 20–60%
- timber moisture content changes between 7–13%




Modulus of elasticity
CLT
- parallel to the grain: 12,500 MPa
- perpendicular to the grain: 370 MPa

LVL
- parallel to the grain: 10,000–13,800 MPa
- perpendicular to the grain: 130–2,400 MPa

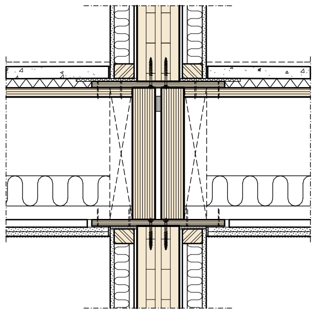



Creep
Creep behaviour in heavy loaded timber structures poses larger deformations.
Timber moisture content affects creep behaviour. Creep is larger when timber is in more humid conditions.

Structural system properties
The largest part of the deformation occurs in CLT wall panels. Also plywood strips between wall panels cause greater deformation than LVL beams.

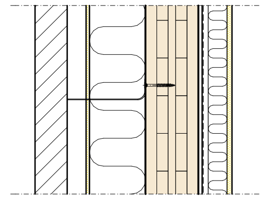
Examples of how to deal with deformations

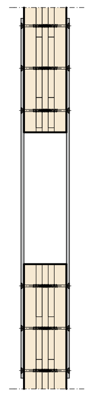
Joints
This structural system has small deformations due to the great amount of vertical wood in the joints. Deformations such as shrinkage and compression cause restraint actions which have to be considered in the joint design.



This joint has small deformation due the amount of vertical wood

Façades with brittle finish

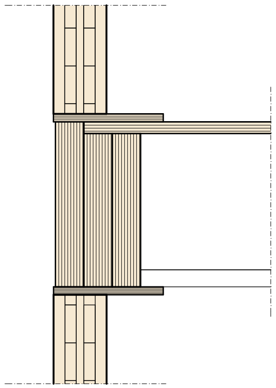




Tension parts need to be calculated to resist restraint actions too

# Example of deformations

Wall (CLT 140 C5s, 2,950 mm):
E = 12,500 MPa
Elastic deformation: 0.05–0.32 mm
Deformation by moisture: 3 mm (5% change)



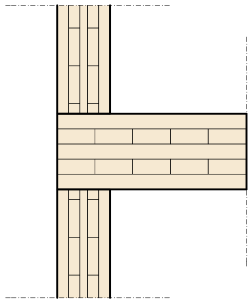
Plywood strip (21 mm, birch):
E = 500 MPa
Elastic deformation: 0.01–0.056 mm
Deformation by moisture: 0.32 mm (5% change)

End beam (75 mm, LVL type S):
E = 10,000 MPa
Elastic deformation: 0.01–0.06 mm
Deformation by moisture: 0.13 mm (3% change)

Plywood strip (21 mm, birch):
E = 500 MPa
Elastic deformation: 0.01–0.056 mm
Deformation by moisture: 0.32 mm (5% change)

Height of storey: ~3,400 mm

Only vertical lamellas of CLT is considered in all layers. Dead load and 30% of live load.



Wall (CLT 140 C5s, 2,950 mm):
E = 12,500 MPa
Elastic deformation: 0.05–0.32 mm
Deformation by moisture: 3 mm (5% change)

Slab (CLT 200 L5s):
E = 370 MPa
Elastic deformation: 0.1–0.71 mm
Deformation by moisture: 2.5 mm (5% change)

Height of storey: ~3,200 mm

## Example of deformations

**1) LVL rib slab and plywood strips located between CLT wall panels**

| 1 storey | Elastic deformation | Deformation by moisture |
|---|---|---|
| gk = 10.5 kN/m | including creep | (5% CLT, 3% LVL) |
| qk = 7 kN/m | 0.06–0.43 mm | 3.5 mm |

7 stories (gk = 73.5 kN/m, qk = 49 kN/m)

Total deformation: 25.3 mm

Deformation is about 3.6 mm for each storey.

**2) CLT slab and wall**

| 1 storey | Elastic deformation | Deformation by moisture |
|---|---|---|
| gk = 10.5 kN/m | including creep | (5% CLT) |
| qk = 7 kN/m | 0.15–1 mm | 5.4 mm |

7 stories (gk = 73.5 kN/m, qk = 49 kN/m)

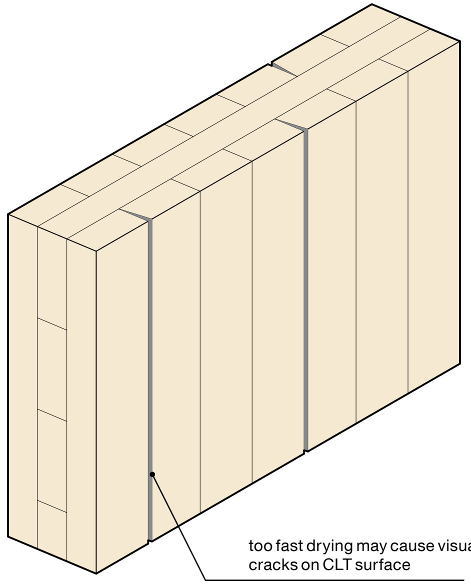
Total deformation: 41.3 mm

Deformation is about 5.9 mm for each storey.

## Cracking

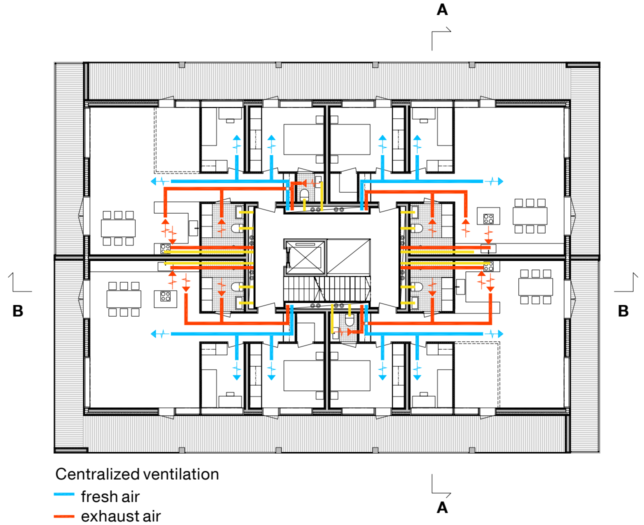
Wood cracks when it exceeds the limit of the tension stress perpendicular to the grain. Normal cracks are included in design principles.

Main reasons for propagation of cracks:
- exceeding tension stresses due to uncontrolled drying for example on-site
- moisture deformations of wood for example from summer to winter



# 4.5 Principles of HVAC design

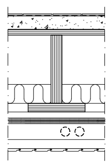
The goal of the HVAC design is to provide thermal comfort and optimal indoor air quality. This section describes the main plumbing routes for a centralized ventilation system. The main routes of ventilation ducts go through suspended ceilings in the horizontal direction and through plumbing cavities in the vertical direction. These cavities are located in the corridors in order to reduce plumbing noise. The goal is to achieve simple, short routes without need for difficult holes through building structures.



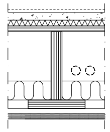

Centralized ventilation
fresh air
exhaust air
sewage

**Options for pipe locations:**

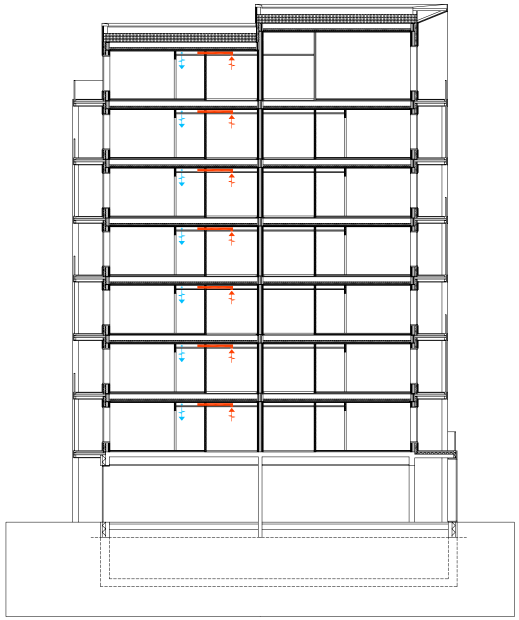
A) Pipes in suspended ceiling



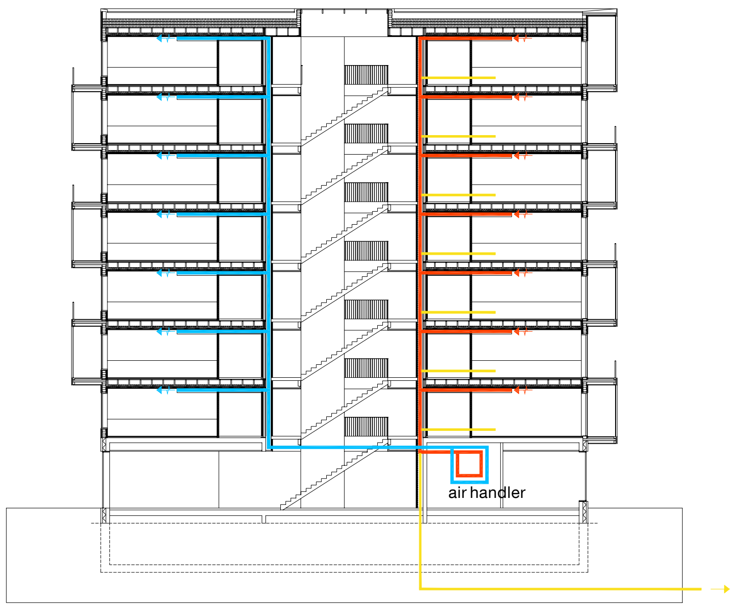
B) Pipes between ribs



Note: penetration through ribs requires careful design



A-A




A-A

Water goes to wastewater treatment plant

# 4.6 Principles of seismic design

Conditions vary, but all buildings in seismic area must be designed to resist seismic forces determined by the requirements of their location and local codes. The example building can be designed according to Eurocode 8 to resist seismic forces.

In earthquake prone areas wood has several advantages:

- low-density (reduced dead loads for structures)
- high strength to weight ratio
- damping is better than in concrete buildings due to the material properties and joints used in wood construction
- modern design codes (such as Eurocode 8) offer clear design principles

## What should be considered in timber house's seismic design?

**Seismic design**

- Conceptual design
- Seismic action
- Details

Stora Enso's massive wall and rib slab system can be designed to be used in seismic areas. This system includes solutions for all three steps in seismic design.

## Seismic action and design

Seismic actions depend on

- construction site ► seismic hazard maps, National Annex EC8
- soil quality
- importance of the building (residential, class II)
- structural system
- the Stora Enso system has a light dead load and connections that have plastic deformations

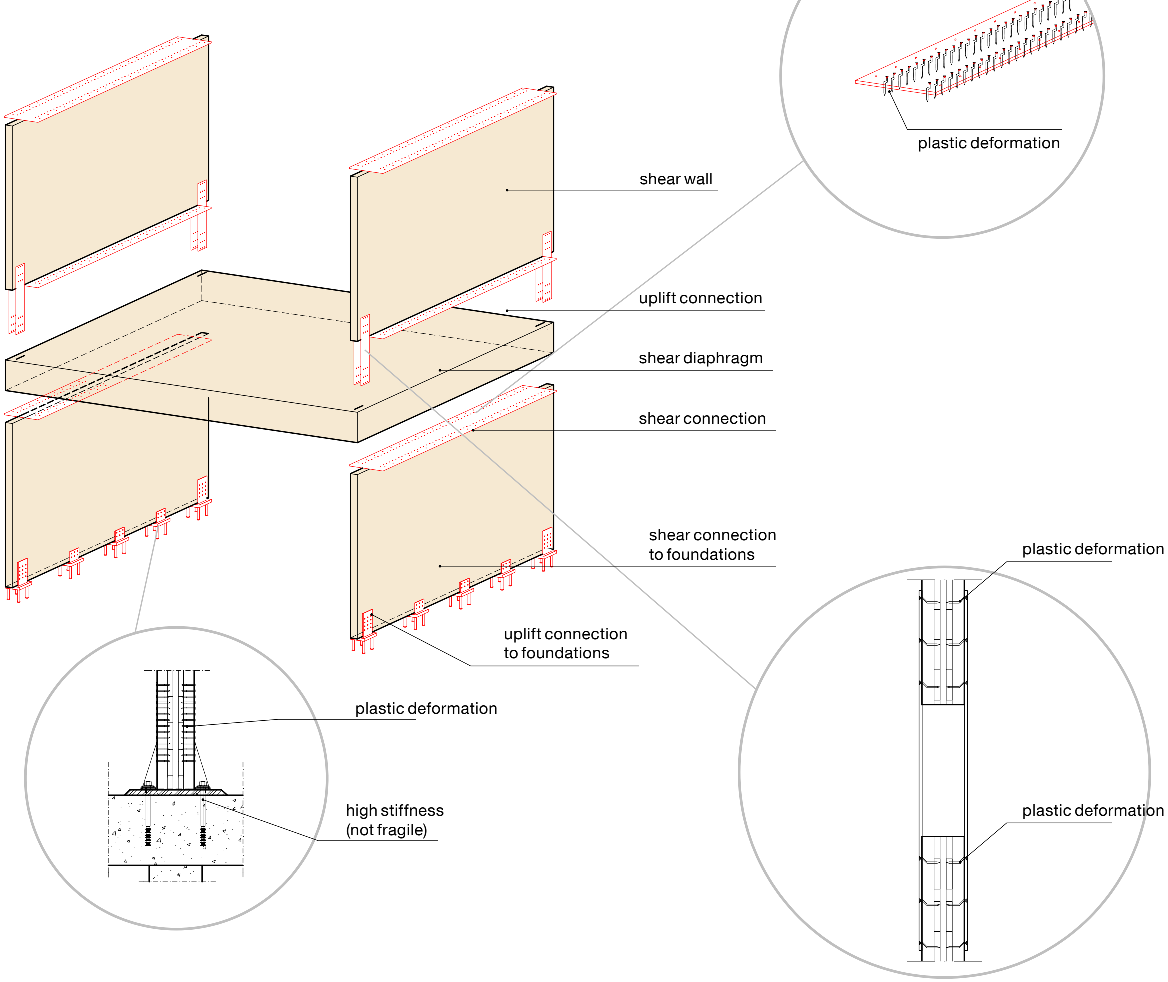
The ductility class for a multi-storey timber building would be DCM and DCH (check EN 1998-1, table 8.1).

- In these classes the behaviour factor q would be about 2–3.

**Notes for details**

a) connections have to be designed for seismic forces

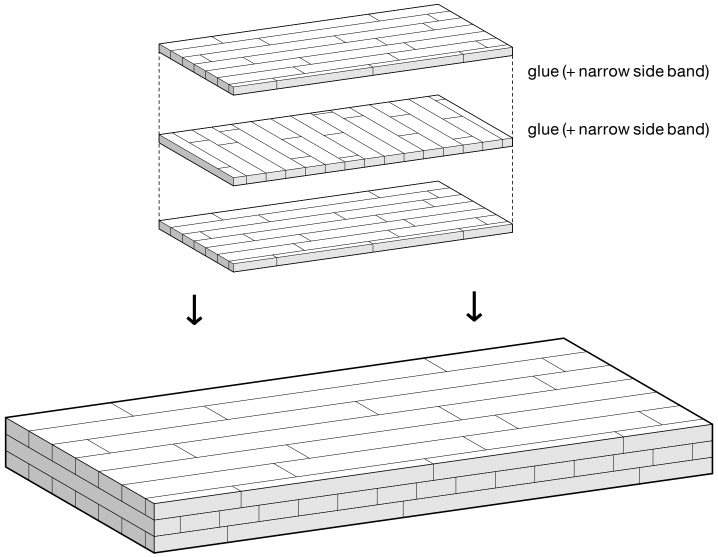
b) no fractile joints (connectors should have enough slenderness)



# 4.7 Frame element production information

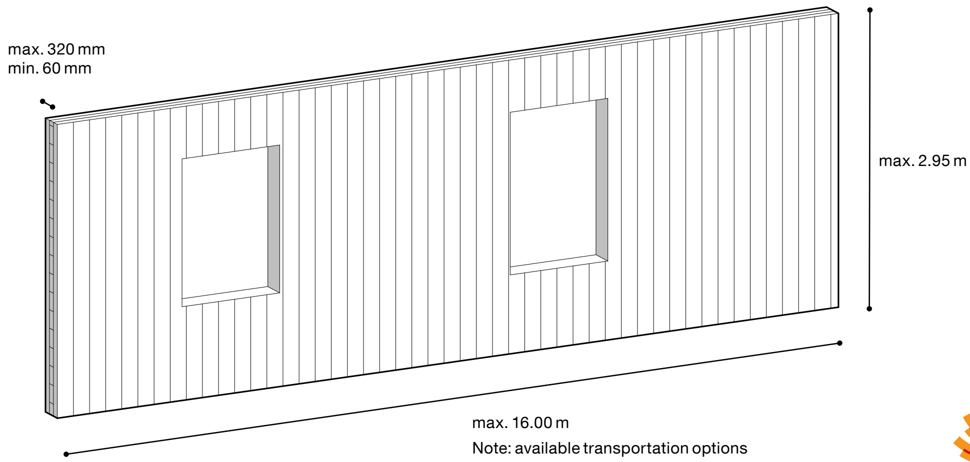
## CLT panel elements

CLT is a massive wood construction product consisting of bonded single-layer panels arranged at right angles to one another. Endless lamella strings are being created by finger joints. On request the cross layer can be edge glued. These single layer boards are being composed to a CLT panel, using face gluing, between each single layer board. Usually the direction of the grain in the single layer boards are perpendicular to the adjacent layers. Top and bottom cover layers are usually oriented in the same direction.




Use
- wall, floor and roof panels

CLT characteristics
- strength grade of layers: C24*
- number of layers: 3, 5, 7, 8
- weight: 5 kN/m$^3$
- moisture content: 7–15%; no more than 5% deviation within one panel




Surface quality
Three options:
- visible quality (VI)
- industrial quality (IVI)
- non-visible quality (NVI)

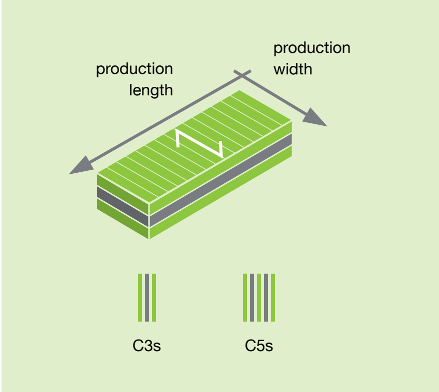
* In accordance with the technical approval 10% to strength class C16 allowed; other grades on request.

Approvals and certificates:
- DIBt Z-9.1.559
- ETA-14/0349

# CLT standard designs

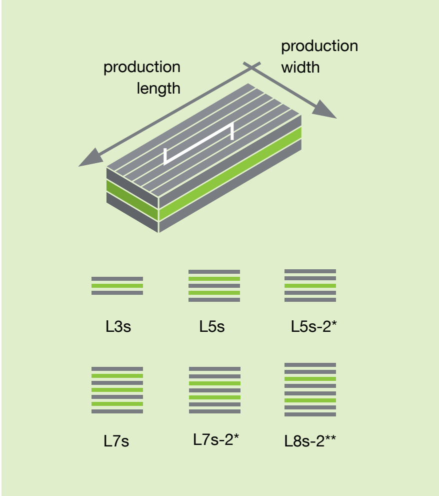
**C panels**
**The grain direction of the cover layers is always parallel to the production widths.**

| Thickness [mm] | Panel type [–] | Layers [–] | Panel design [mm] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | C*** | L | C*** | L | C*** | L | C*** |
| 60 | C3s | 3 | 20 | 20 | 20 | | | | |
| 80 | C3s | 3 | 20 | 40 | 20 | | | | |
| 90 | C3s | 3 | 30 | 30 | 30 | | | | |
| 100 | C3s | 3 | 30 | 40 | 30 | | | | |
| 120 | C3s | 3 | 40 | 40 | 40 | | | | |
| 100 | C5s | 5 | 20 | 20 | 20 | 20 | 20 | | |
| 120 | C5s | 5 | 30 | 20 | 20 | 20 | 30 | | |
| 140 | C5s | 5 | 40 | 20 | 20 | 20 | 40 | | |
| 160 | C5s | 5 | 40 | 20 | 40 | 20 | 40 | | |




**L panels**
**The grain direction of the cover layers is always at right angles to the production widths.**

| Thickness [mm] | Panel type [–] | Layers [–] | Panel design [mm] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | C | L | C | L | C | L |
| 60 | L3s | 3 | 20 | 20 | 20 | | | | |
| 80 | L3s | 3 | 20 | 40 | 20 | | | | |
| 90 | L3s | 3 | 30 | 30 | 30 | | | | |
| 100 | L3s | 3 | 30 | 40 | 30 | | | | |
| 120 | L3s | 3 | 40 | 40 | 40 | | | | |
| 100 | L5s | 5 | 20 | 20 | 20 | 20 | 20 | | |
| 120 | L5s | 5 | 30 | 20 | 20 | 20 | 30 | | |
| 140 | L5s | 5 | 40 | 20 | 20 | 20 | 40 | | |
| 160 | L5s | 5 | 40 | 20 | 40 | 20 | 40 | | |
| 180 | L5s | 5 | 40 | 30 | 40 | 30 | 40 | | |
| 200 | L5s | 5 | 40 | 40 | 40 | 40 | 40 | | |
| 160 | L5s-2* | 5 | 60 | 40 | 60 | | | | |
| 180 | L7s | 7 | 30 | 20 | 30 | 20 | 30 | 20 | 30 |
| 200 | L7s | 7 | 20 | 40 | 20 | 40 | 20 | 40 | 20 |
| 240 | L7s | 7 | 30 | 40 | 30 | 40 | 30 | 40 | 30 |
| 220 | L7s-2* | 7 | 60 | 30 | 40 | 30 | 60 | | |
| 240 | L7s-2* | 7 | 80 | 20 | 40 | 20 | 80 | | |
| 260 | L7s-2* | 7 | 80 | 30 | 40 | 30 | 80 | | |
| 280 | L7s-2* | 7 | 80 | 40 | 40 | 40 | 80 | | |
| 300 | L8s-2** | 8 | 80 | 30 | 80 | 30 | 80 | | |
| 320 | L8s-2** | 8 | 80 | 40 | 80 | 40 | 80 | | |




* cover layers consisting of two lengthwise layers
** cover layers and inner layer consisting of two lengthwise layers
*** with C panels, the sanding direction is at right angles to the grain

**Production widths:** 245 cm, 275 cm, 295 cm
**Production lengths:** from minimum production length of 8.00 m per charged width up to max. 16.00 m (in 10 cm increments)

# LVL rib slab

The LVL rib slab is a factory-made structural component constructed from Laminated Veneer Lumber (LVL) panels and beams.

Structurally glued product

- rigid connections between slab, rib and chord elements
- gluing is carried out according to tested and approved gluing methods

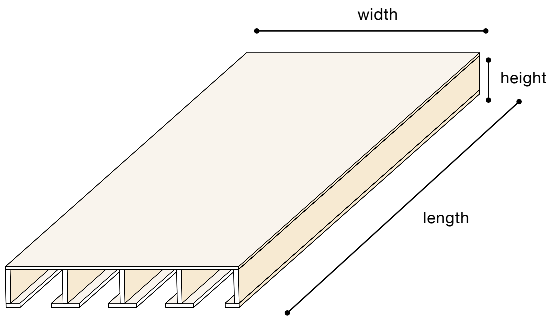
ETA / CE marked product

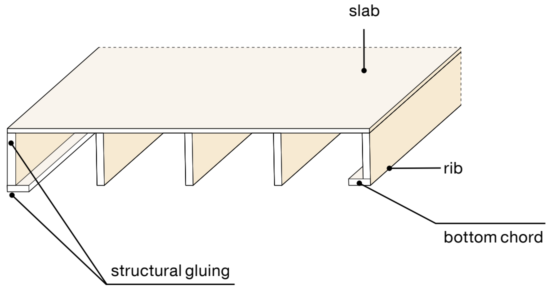
- Rib slabs are designed according to EC5 and product specific rules defined in the ETA. The structures can be designed for R60 and R90 classes.

Structurally optimized cross-section

- The combination of ribs and panels optimizes material use.
- Elements are more material efficient than a solid CLT slab.

The product takes advantage of the superior material properties of LVL, using the top slab as a bracing diaphragm for the building. The high stiffness and strength of the elements enables good load-bearing capacity and long spans. The product is especially good when EC vibration criteria are considered.




Slab:

- LVL type X
- recommended: 26–32 mm
- range: 23–68 mm
- main veneer direction is same as bearing direction

Rib:

- LVL type S
- recommended: 45–57 mm
- range: 27–75 mm

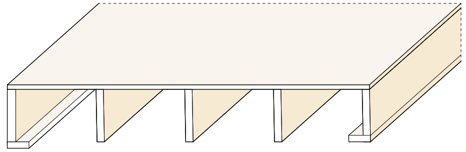
Bottom chord:

- LVL type S
- recommended: 32–56 mm
- range: 26–74 mm

Possible dimensions:
Width: 2,400–2,500 mm
(adjustable in projects)
Length: up to 10 m

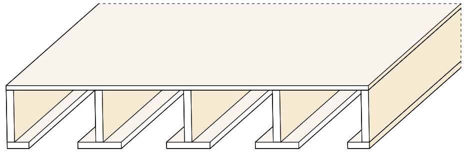
- according to structural design
- height: 200–700 mm
- according to structural design
- count of ribs: 4–5

**Optional element types**
Three different types.



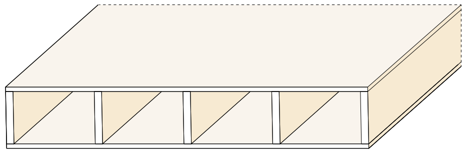
Basic

- basic solution
- easy production technology
- flexible



Open box construction

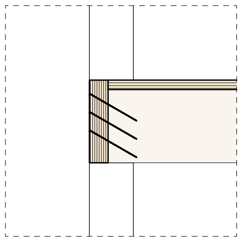
- optimized product for multi-storey houses
- high stiffness
- easy erection of acoustic insulation
- open box for HVAC installations



Closed box construction

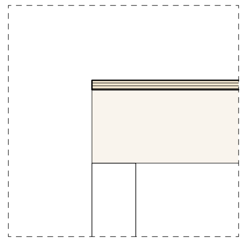
- highest stiffness properties with low structural height
- bottom slab can be used as visual structure

## End of the slab



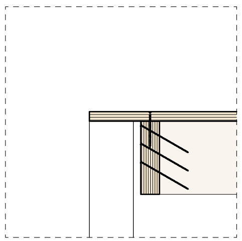
End beam

- type X LVL
- vertical load in wall pass end beam
- minimum deformation



Simple support

- rib slab is supported by load-bearing wall



Support by top slab

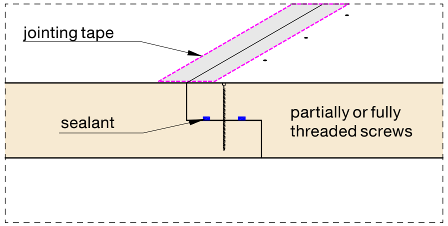
- minimized total structural height

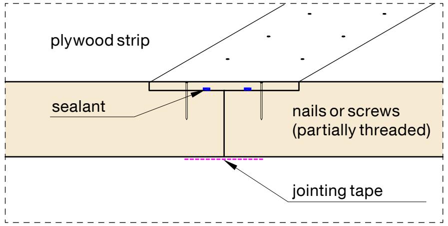
# 4.8 Basic joints

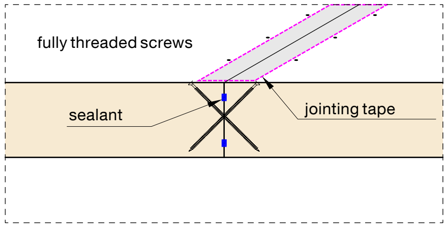
Basic joints can usually be achieved using screws and nails. These joints are applicable in many cases, however fasteners and hardware must be scaled according to the specific requirements for each connection.

**Joints (CLT)**

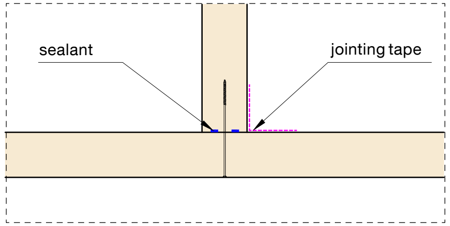
Longitudinal panel joints

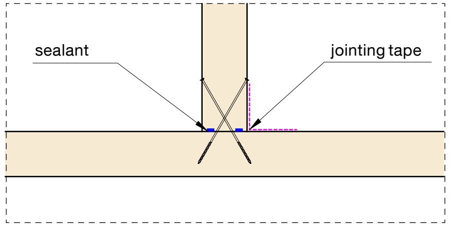


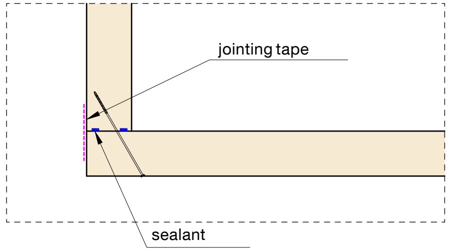




Wall to wall connections using partially threaded screws



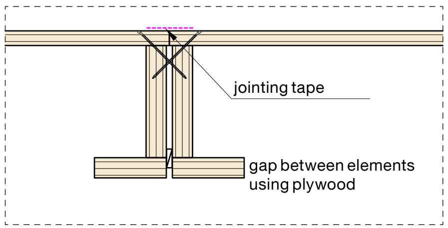

— sealant

or

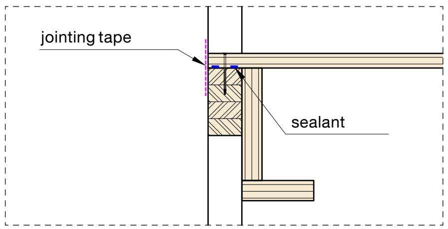
----- jointing tape

**Joints (rib slab)**

Longitudinal joint



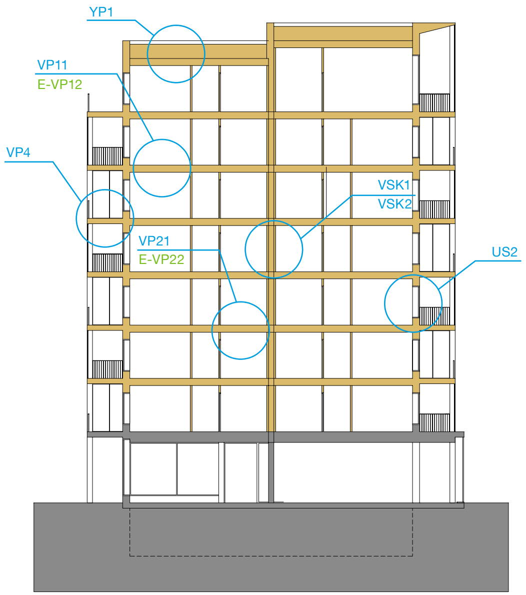

Slab to beam connection

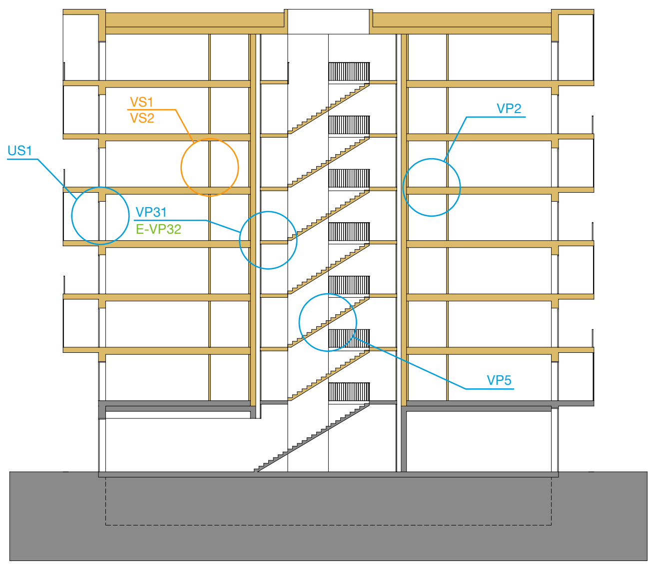


# 5 Structural design

# 5.1 Structural types

Orientation Chart



# List of Drawings

| Structural type | No. | | Description |
|---|---|---|---|
| US | 1 | | LOAD-BEARING EXTERNAL WALL |
| | | A | Render, glass wool, visual CLT |
| | | B | Render, wood fibre insulation, visual CLT |
| | | C | Wood cladding, mineral wool, visual CLT |
| | | D | Wood cladding, lightweight inner partition |
| | | E | Tile cladding, lightweight inner partition |
| US | 2 | | NON-LOAD-BEARING EXTERNAL WALL |
| | | A | Render, stone wool |
| | | B | Wood cladding, lightweight inner partition |
| | | C | Wood cladding, wood fibre insulation, plumbing cavity |
| VSK | 1 | | LOAD-BEARING PARTITION WALL |
| | | A | Lightweight inner partition, both sides |
| | | B | Lightweight inner partition,double gypsum boards |
| | | C | Lightweight inner partition, one side, double gypsum boards |
| | | D | Double CLT |
| | | E | Lightweight inner partition, both sides, service shaft |
| | | F | Double CLT, gypsum boards |
| VSK | 2 | | LOAD-BEARING PARTITION WALL, BATHROOM |
| | | A | Lightweight inner partition, waterproofing |
| | | B | Lightweight inner partition, waterproofing, double gypsum boards |
| | | C | Lightweight inner partition, waterproofing, double CLT + boards |
| VSK | 3 | | LOAD-BEARING PARTITION WALL, ELEVATOR SHAFT |
| | | A | CLT |
| | | B | CLT, gypsum boards |
| | | C | Concrete |
| VP | 11 | | RIB SLAB INTERMEDIATE FLOOR, APARTMENT |
| | | A | Floating floor slab, suspended ceiling |
| | | B | Gypsum boards, timber panelling |
| | | C | Gypsum boards, suspended ceiling |
| VP | 21 | | RIB SLAB INTERMEDIATE FLOOR, BATHROOM |
| | | A | Concrete slab, rib slab, suspended ceiling and panelling |
| VP | 31 | | CLT SLAB INTERMEDIATE FLOOR, CORRIDOR |
| | | A | Surface layer, visual CLT |
| | | B | Surface layer, CLT, suspended ceiling |
| | | C | Floating floor, CLT, suspended ceiling, double gypsum boards |
| VP | 4 | | CLT SLAB INTERMEDIATE FLOOR, BALCONY |
| | | A | Surface layer, visible CLT |

| | | | |
|---|---|---|---|
| VP | 5 | | STAIRS |
| | | A | CLT stairs, load-bearing CLT handrails |
| | | B | CLT stairs, CLT slab |
| | | C | CLT steps, gluelam beams, insulation |
| | | D | Plywood steps, nail plate connected beams, insulation |
| | | E | Concrete stairs |
| YP | 1 | | ROOF STRUCTURE |
| | | A | Timber truss roof |
| | | B | Timber truss roof, LVL bottom chord |
| | | C | Timber beam roof |
| | | D | LVL rib slab |
| | | E | LVL rib slab |
| VS | 1 | | NON-LOAD-BEARING PARTITION WALL |
| | | A | Timber or steel frame |
| | | B | CLT |
| VS | 2 | | NON-LOAD-BEARING PARTITION WALL, BATHROOM |
| | | A | Timber or steel frame, bathroom |
| | | B | CLT, bathroom |
| E-VP | 12 | | CLT SLAB INTERMEDIATE FLOOR, APARTMENT |
| | | A | Floating floor slab, suspended ceiling |
| | | B | Floating floor slab, visual CLT |
| | | C | Floating floor slab, concrete-CLT composite, visual CLT |
| | | D | Floating floor slab, concrete-CLT composite, suspended ceiling |
| | | E | Floating floor slab, chippings (gravel), visual CLT |
| E-VP | 22 | | CLT SLAB INTERMEDIATE FLOOR, BATHROOM |
| | | A | Concrete slab, CLT, suspended ceiling and panelling |
| | | B | Concrete slab, CLT, gypsum boards, suspended ceiling and panelling |
| E-VP | 32 | | RIB SLAB INTERMEDIATE FLOOR, CORRIDOR |
| | | A | Floating floor, rib slab, suspended ceiling, double gypsum boards |

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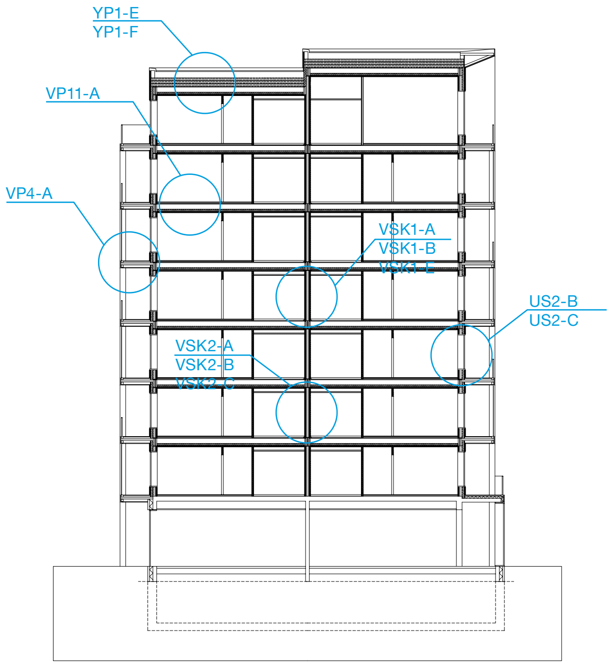
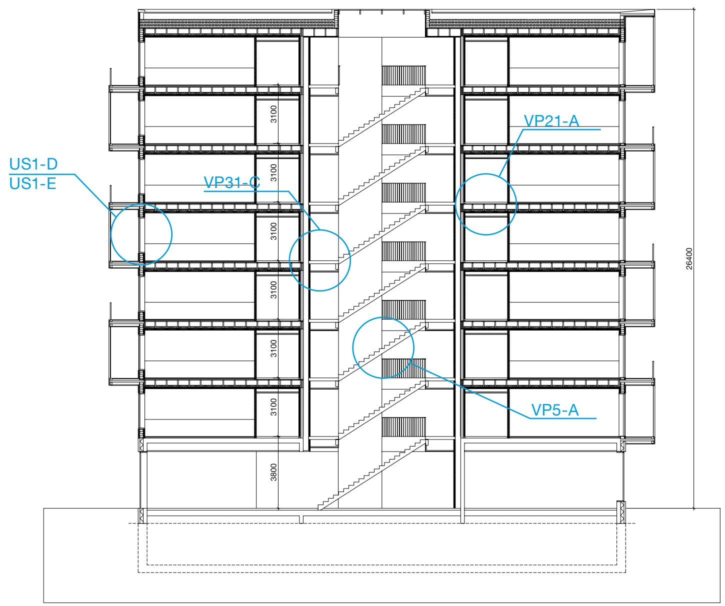
# Case study, structural types

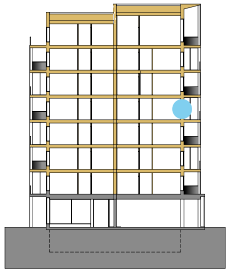
Structural types which may be used in case study building are marked with blue colour.

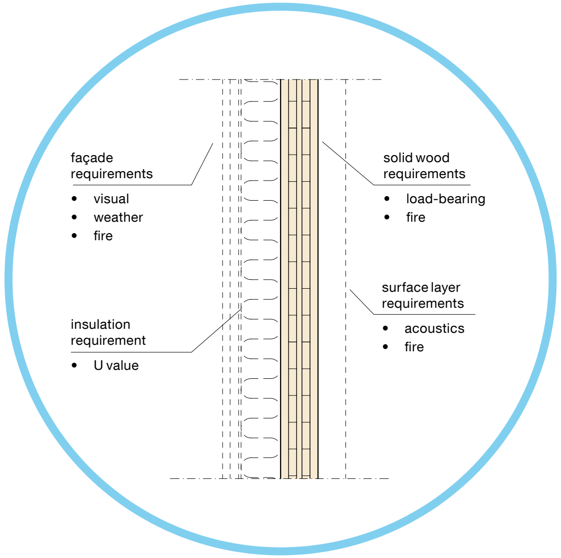



# US 1

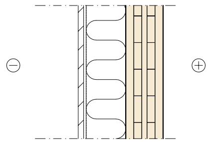
## Load-bearing external wall





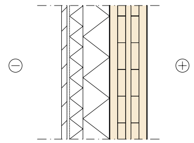

## Variables

### A. Render, glass wool, visual CLT



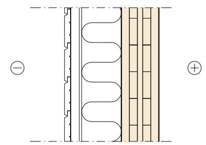

**Structure**
- render + render board [10–30 mm]****
- glass wool insulation*
- CLT [140 mm]**

### B. Render, wood fibre insulation, visual CLT



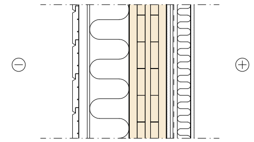

**Structure**
- render + render board [10–30 mm]****
- timber frame + wood fibre insulation*
- CLT [140 mm]**

### C. Wood cladding, mineral wool, visual CLT



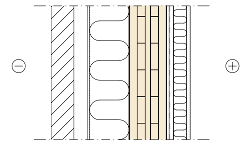

**Structure**
- façade material*
- ventilation [32 mm]
- sheathing board [9 mm]
- timber frame + insulation*
- CLT [140 mm]**

### D. Wood cladding, lightweight inner partition




**Structure**
- façade material*
- ventilation [32 mm]
- sheathing board [9 mm]
- timber frame + insulation*
- CLT [140 mm]**
- gypsum board* (if fire or acoustics required)
- air gap*** [10 mm] + punctual fastening
- foil according to local climatic conditions
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- gypsum board*

### E. Tile cladding, lightweight inner partition




**Structure**
- façade material*
- ventilation [32 mm]
- sheathing board [9 mm]
- timber frame + insulation*
- CLT [140 mm]**
- air gap*** [10 mm] + punctual fastening
- foil according to local climatic conditions
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- gypsum board*

Charring values used for CLT cross-section calculation are calculated according to zero strength layer theory presented in EN 1995-1-2.

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

| Type | Insulation | Surface material | Thickness (CLT 140) | Minimum CLT cross-section (see 4.3) | | | | U [W/m²K] | Surface reaction to fire | | Rw (C; Ctr) [dB] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | R60 | | R90 | | | | | |
| | | | | 4 stories | 7 stories | 4 stories | 7 stories | | Inner | Outer | |
| A.0 | 150 mm | visible CLT | 318 mm | 140 C5s | 140 C5s | 140 C5s | 140 C5s | 0.217 | D-s2, d0 | – | 42 (–2; –6) |
| A.1 | 180 mm | visible CLT | 348 mm | 140 C5s | 140 C5s | 140 C5s | 140 C5s | 0.189 | D-s2, d0 | – | 42 (–2; –6) |
| B.0 | 150 mm | visible CLT | 320 mm | 140 C5s | 140 C5s | 140 C5s | 140 C5s | 0.209 | D-s2, d0 | – | 42 (–2; –6) |
| C.0 | 150 mm | visible CLT | 352 mm | 140 C5s | 140 C5s | 140 C5s | 140 C5s | 0.203 | D-s2, d0 | D-s2, d0 | 40 (–2; –7) |
| D.0 | 150 mm | gypsum boards [15 + 13 mm] | 456 mm | 100 C3s | 100 C3s | 120 C5s | 120 C5s | 0.158 | A2-s1,d0 | D-s2, d0 | 48 (–2; –5) |
| D.1 | 120 mm | gypsum board [13 mm] | 411 mm | 140 C5s | 140 C5s | 140 C5s | 140 C5s | 0.179 | A2-s1,d0 | D-s2, d0 | 49 (–2; –5) |
| E.0 | 150 mm | gypsum boards [15 + 13 mm] | 521 mm | 100 C3s | 100 C3s | 120 C5s | 120 C5s | 0.160 | A2-s1,d0 | – | 56 (–1; –3) |
| E.1 | 120 mm | visible CLT | 402 mm | 140 C5s | 140 C5s | 140 C5s | 140 C5s | 0.235 | D-s2, d0 | – | 56 (–1; –3) |

Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics
**** for render and included details, look at the manufacturer's guide

These minimum CLT cross sections are calculated for walls in cases where three or six stories are loading them. For exact loading considered, see 4.3 (walls 1 and 3, exterior wall).

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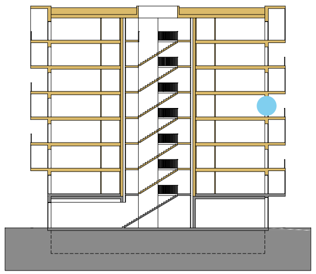
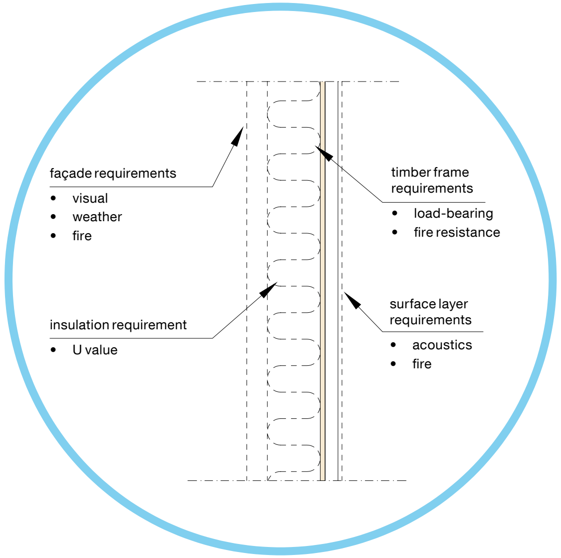
# US 2

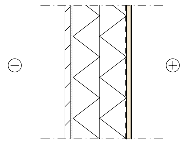
## Non-load-bearing external wall





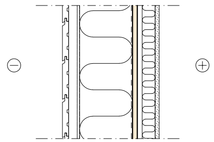

## Variables

### A. Render, stone wool



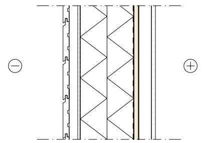
**Structure**
- render + render board [10–30 mm] ****
- timber frame
- (soft connection to the frame required) + stone wool [minimum 150 mm]
- vapour barrier
- OSB board [18 mm]

### B. Wood cladding, lightweight inner partition



**Structure**
- cladding [28 mm]
- ventilation [32 mm]
- sheathing board [9 mm]
- timber frame ** + insulation [200 mm]
- vapour barrier
- OSB board [18 mm]
- timber (or steel) frame + insulation [50 mm]
- gypsum board * [15 mm] (or wood based panel [15 mm])

### C. Wood cladding, wood fibre insulation, plumbing cavity



**Structure**
- cladding [28 mm]
- ventilation [32 mm]
- sheathing board [9 mm]
- timber frame ** + wood fibre insulation [200 mm]
- hygroscopic membrane
- OSB board [18 mm]
- timber (or steel) frame [50 mm] (plumbing cavity)
- gypsum board [15 mm]

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

| Type | Insulation | Surface material | Thickness (CLT 140) | Fire resistance | U [W/m²K] | Surface reaction to fire | | Rw (C; Ctr) [dB] |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Inner | Outer | |
| A.0 | 200 mm | OSB board [18 mm] | 248 mm | – | 0.204 | D-s2, d0 | – | 47 (–3; –10) |
| B.0 | 200 mm | gypsum board [15 mm] | 343 mm | – | 0.166 | A2-s1,d0 | – | 46 (–2; –5) |
| B.1 | 200 mm | wood based panel | 343 mm | – | 0.165 | D-s2, d0 | – | 45 (–2; –5) |
| C.0 | 200 mm | gypsum board [15 mm] | 343 mm | – | 0.201 | A2-s1,d0 | D-s2, d0 | 45 (–2; –5) |

Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics
**** for render and included details, look at the manufacturer's guide

These minimum CLT cross sections are calculated for walls in cases where three or six stories are loading them. For exact loading considered, see 4.3 (walls 1 and 3, exterior wall).

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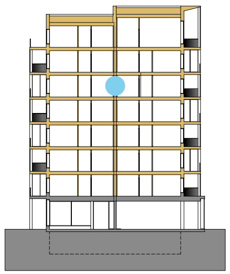
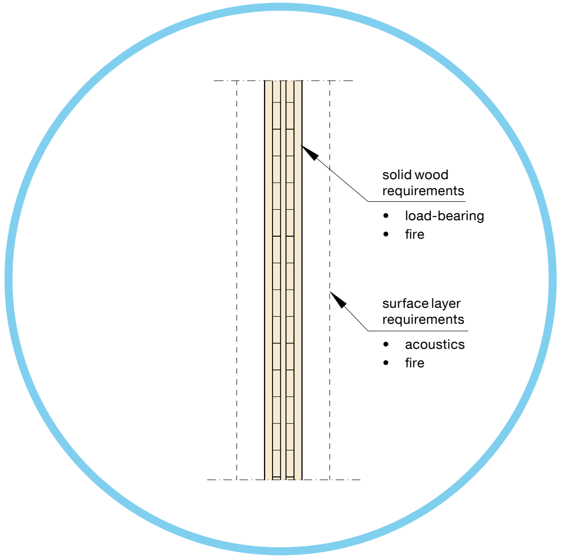
# VSK 1

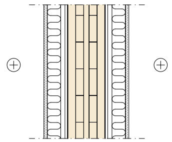
## Load-bearing partition wall





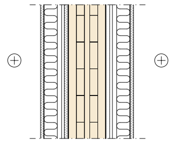

## Variables

### A. Lightweight inner partition, both sides



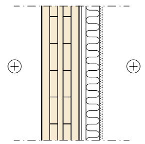
**Structure**
- gypsum board [12 kg/m²; 13 mm; 2 × 18 mm]
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- air gap*** [10 mm] + punctual fastening
- CLT** [140 mm]
- air gap*** [10 mm] + punctual fastening
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- gypsum board [12 kg/m²; 13 mm; 2 × 18 mm]

### B. Lightweight inner partition, double gypsum boards



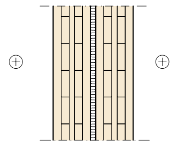
**Structure**
- gypsum board [12 kg/m²; 13 mm; 2 × 18 mm]
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- air gap*** [10 mm] + punctual fastening
- gypsum board [15 mm]
- CLT** [140 mm]
- gypsum board [15 mm]
- air gap*** [10 mm] + punctual fastening
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- gypsum board [12 kg/m²; 13 mm; 2 × 18 mm]

### C. Lightweight inner partition, one side, double gypsum boards



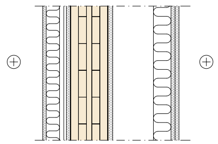
**Structure**
- CLT** [140 mm]
- (soft connection to the frame required)
- air gap*** [10 mm] + punctual fastening
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- gypsum board [12 kg/m²; 13 mm; 2 × 18 mm]

### D. Double CLT



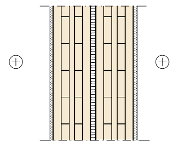
**Structure**
- CLT** [140 mm]
- mineral wool [20–50 mm]
- CLT** [140 mm]

### E. Lightweight inner partition, both sides, service shaft



**Structure**
- gypsum board [12 kg/m²; 13 mm; 2 × 18 mm]
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- air gap*** [10 mm] + punctual fastening
- gypsum board [15 mm]
- CLT** [140 mm]
- gypsum board [18 mm]
- plumbing cavity
- steel frame + insulation [50 mm]
- 2 gypsum boards [15 mm]

### F. Double CLT, gypsum boards



**Structure**
- gypsum board [15 mm; min. 12 kg/m²]
- CLT** [140 mm]
- mineral wool [40–70 mm]
- CLT** [140 mm]
- gypsum board [15 mm; min. 12 kg/m²]

Charring values used for CLT cross-section calculation are calculated according to zero strength layer theory presented in EN 1995-1-2.

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

| Type | Insulation | Materials | Thickness (CLT 140) | Minimum CLT cross-section (see 4.3) | | | | Surface reaction to fire | Rw (C; Ctr) [dB] |
|---|---|---|---|---|---|---|---|---|---|
| | | | | R60 | | R90 | | | |
| | | | | 4 stories | 7 stories | 4 stories | 7 stories | | |
| A.0 | 100 mm | steel studs, gypsum boards [13 mm] | 318 mm | 140 C5s | 140 C5s | 140 C5s | 160 C5s | A2-s1,d0 | 57 (–3, –9) |
| A.1 | 100 mm | steel studs, gypsum boards [13 mm] (punctual fastening only at floor and ceiling level) | 318 mm | 140 C5s | 140 C5s | 140 C5s | 160 C5s | A2-s1,d0 | 59 (–3; –6) |
| B.0 | 100 mm | steel studs, gypsum boards [15 + 13 mm] | 348 mm | 100 C3s | 120 C3s | 120 C5s | 140 C5s | A2-s1,d0 | 55 (–3; –5) |
| B.1 | 100 mm | steel studs, gypsum boards [15 + 13 mm] (punctual fastening only at floor and ceiling level) | 348 mm | 100 C3s | 120 C3s | 120 C5s | 140 C5s | A2-s1,d0 | 61 (–2; –5) |
| C.0 | 50 mm | timber frame, gypsum board [13 mm] / CLT | 229 mm | 140 C5s | 140 C5s | 140 C5s | 140 C5s | A2-s1,d0/ D-s2, d0 | 43 (–2; –7) |
| C.1 | 50 mm | steel studs, gypsum boards [13 mm] (gypsum board weight > 920 kg/m³) / CLT | 229 mm | 140 C5s | 140 C5s | 140 C5s | 140 C5s | A2-s1,d0/ D-s2, d0 | 52 (–2; –6) |
| D.0 | 50 mm | visible CLT | 300 mm | 140 C5s | 140 C5s | 140 C5s | 140 C5s | D-s2, d0 | 53 (–2; –7) |
| E.0 | 100 mm | timber frame, gypsum boards [13 + 15 mm] / 2 × 15 + 18 mm | 511 mm | 100 C3s | 120 C3s | 120 C5s | 140 C5s | A2-s1,d0 | 56 (–3; –4) |
| E.1 | 100 mm | steel studs, gypsum boards [13 + 15 mm] / 2 × 15 + 18 mm (gypsum board weight > 920 kg/m³) | 511 mm | 100 C3s | 120 C3s | 120 C5s | 140 C5s | A2-s1,d0 | 59 (–3, –4) |
| F.0 | 20 mm | gypsum boards [15 mm] | 330 mm | 120 C3s | 140 C5s | 140 C5s | 140 C5s | A2-s1,d0 | 56 (–2, –7) |

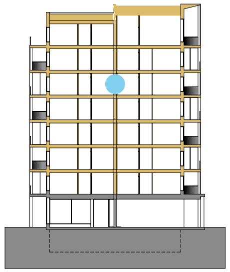
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

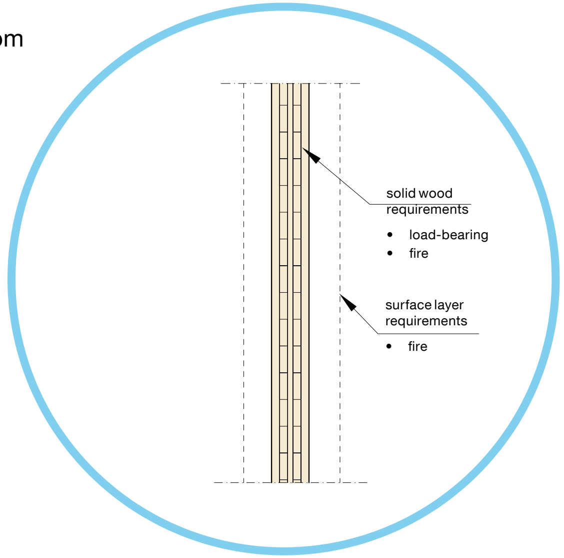
* variable
** according to structural calculations
*** air gap due to acoustics
**** for render and included details, look at the manufacturer's guide

These minimum CLT cross sections are calculated for walls in cases where three or six stories are loading them. For exact loading considered, see 4.3 (walls 2 and 4, interior wall).

# VSK 2

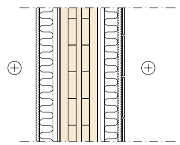
## Load-bearing partition wall, bathroom






## Variables

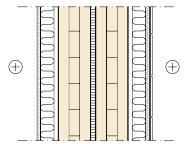
### A. Lightweight inner partition, waterproofing



**Structure**

- gypsum board [12 kg/m²; 12 mm; 2 × 18 mm]
- steel frame wall [66 mm] + insulation [50 mm]
- air gap*** [10 mm] + punctual fastening
- CLT** [140 mm]
- air gap*** [10 mm] + punctual fastening
- steel frame wall [66 mm] + insulation [50 mm]
- moisture resistant board [13 mm]
- certified waterproofing system
- tile adhesive
- tiles

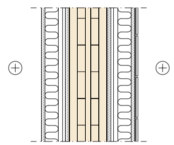
### A. Lightweight inner partition, waterproofing, double CLT + boards



**Structure**

- gypsum board [12 kg/m²; 12 mm; 2 × 18 mm]
- steel frame wall [66 mm] + insulation [50 mm]
- air gap*** [10 mm] + punctual fastening
- CLT** [120 mm]
- insulation [40 mm]
- CLT** [120 mm]
- air gap*** [10 mm] + punctual fastening
- steel frame wall [66 mm] + insulation [50 mm]
- moisture resistant board [13 mm]
- certified waterproofing system
- tile adhesive
- tiles

### B. Lightweight inner partition, waterproofing, double gypsum boards



**Structure**

- gypsum board [12 kg/m²; 12 mm; 2 × 18 mm]
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- air gap*** [10 mm] + punctual fastening
- gypsum board [15 mm]
- CLT** [140 mm]
- gypsum board [15 mm]
- air gap*** [10 mm] + punctual fastening
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- moisture resistant board [13 mm]
- certified waterproofing system
- tile adhesive
- tiles

Charring values used for CLT cross-section calculation are calculated according to zero strength layer theory presented in EN 1995-1-2.

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

| Type | Insulation | Surface material | Thickness (CLT 140 / 2 × CLT 120) | Minimum CLT cross section (see 4.3) | | | | Surface reaction to fire | Rw (C; Ctr) [dB] |
|---|---|---|---|---|---|---|---|---|---|
| | | | | R60 | | R90 | | | |
| | | | | 4 stories | 7 stories | 4 stories | 7 stories | | |
| A.0 | 100 mm | steel studs, gypsum boards [13 mm] / tiles (punctual fastening only at floor and ceiling level) | 330 mm | 140 C5s | 140 C5s | 140 C5s | 160 C5s | A2-s1,d0 / — | 59 (–3, –9) |
| B.0 | 100 mm | steel studs, gypsum boards [15 + 13 mm] / tiles (punctual fastening only at floor and ceiling level) | 360 mm | 100 C3s | 120 C3s | 120 C5s | 140 C5s | A2-s1,d0 / — | 61 (–2, –7) |
| C.0 | 100 mm | steel studs, gypsum boards [13 mm] / tiles (punctual fastening only at floor and ceiling level) | 430 mm | 140 C5s | 140 C5s | 160 C5s | 160 C5s | A2-s1,d0 / — | 58 (–2, –6) |

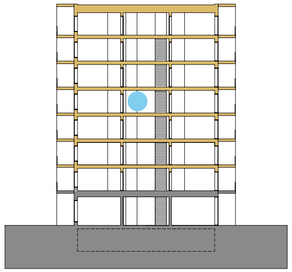
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

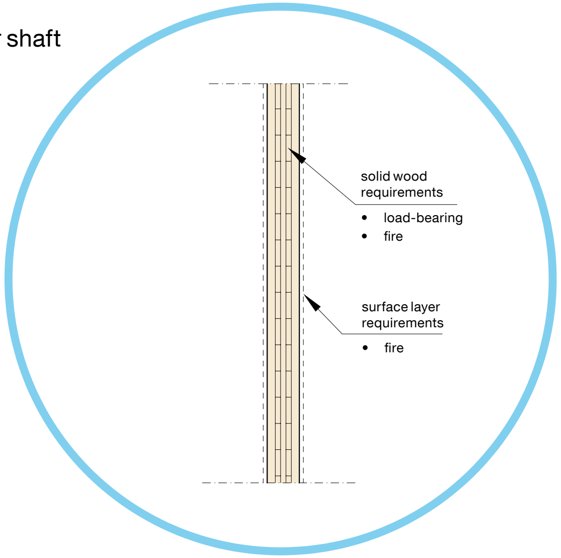
* variable
** according to structural calculations
*** air gap due to acoustics
**** for render and included details, look at the manufacturer's guide

These minimum CLT cross sections are calculated for walls in cases where three or six stories are loading them. For exact loading considered, see 4.3 (walls 2 and 4, interior wall).

# VSK 3

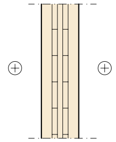
## Load-bearing partition wall, elevator shaft





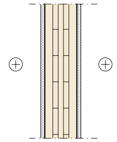

## Variables

**A. CLT**



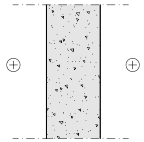
**Structure**
- CLT** [140 mm]

**B. CLT, gypsum boards**



**Structure**
- gypsum board [15 mm]
- CLT** [120 mm]
- gypsum board [15 mm]

**C. Concrete**



**Structure**
- reinforced concrete** [200 mm]

Charring values used for CLT cross-section calculation are calculated according to zero strength layer theory presented in EN 1995-1-2.

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

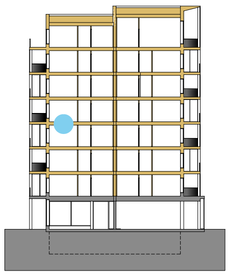
| Type | Insulation | Surface material | Thickness (CLT 140/ 120) | Fire resistance | Surface reaction to fire | Charring R60 | Charring R90 | Rw (C; Ctr) [dB] |
|---|---|---|---|---|---|---|---|---|
| A.0 | – | visible CLT | 140 mm | – | D-s2, d0 | 46 mm | 65 mm | 36 (–1; –3) |
| B.0 | – | gypsum boards [15 mm] | 150 mm | – | A2-s1,d0 | – | – | 38 (–1; –3) |
| C.0 | – | concrete | 200 mm | – | A1 | – | – | 56 (–2; –6) |

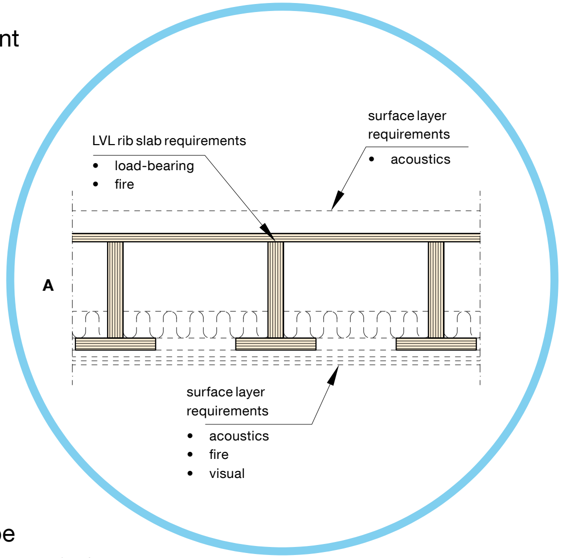
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics

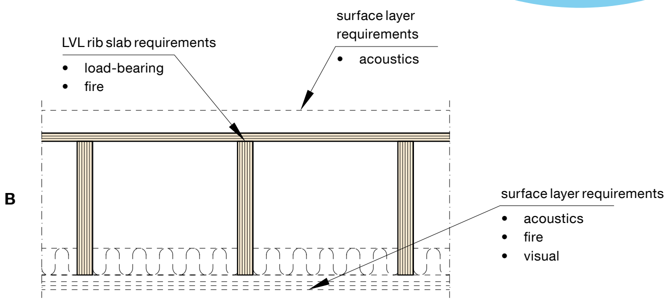
# VP 11

## Rib slab intermediate floor, apartment



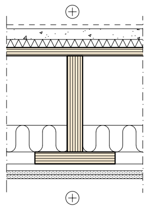



## Alternative rib slab shape



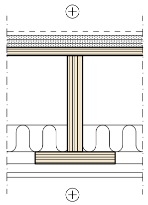

## Variables

### A. Floating floor slab, suspended ceiling



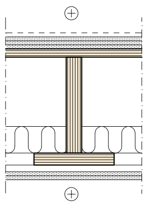
**Structure**
- floating screed slab* [40 mm]
- filter cloth
- impact sound isolation [30 mm]
- LVL rib slab** [435 mm] + insulation [100 mm]
- resilient channel [25 mm]
- gypsum board* [2 × 15 mm]

### B. Gypsum boards, timber panelling



**Structure**
- floor gypsum board [3 × 15 mm]
- LVL rib slab** [435 mm]
  + insulation [100 mm]
  (soft connection to the frame required)
- battening [32 mm]
- 3-layer board [18 mm, visual quality]

### C. Gypsum boards, suspended ceiling



**Structure**
- floor gypsum board [3 × 15 mm]
- LVL rib slab** [435 mm] + insulation [100 mm]
- resilient channel [25 mm]
- gypsum board [2 × 15 mm]

| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | | Rw (C; Ctr) [dB] | Ln,w (Ci) [dB] |
|---|---|---|---|---|---|---|---|---|
| | | | | | Floor | Ceiling | | |
| A.0 | 130 mm | floor slab [40 mm; without carpet] / 2 gypsum boards [15 mm] | 561 mm | REI 60 | – | A2-s1,d0 | 63 (–1; –5) | 50 (0) |
| A.1 | 130 mm | floor slab [80 mm; without carpet] / gypsum board [15 mm] + 3-layer board [21 mm] | 607 mm | – | – | A2-s1,d0 | 60 (–1; –6) | 52 (0) |
| A.2 | 130 mm | floor slab [40 mm; with carpet; ΔLw > 25 dB] / 2 gypsum boards [15 mm] | 561 mm | – | – | A2-s1,d0 | 63 (–1; –5) | 42 (0) |
| A.3 | 130 mm | floor slab [80 mm; with carpet; ΔLw > 25 dB] / gypsum board [15 mm] + 3-layer board [21 mm] | 607 mm | – | – | A2-s1,d0 | 60 (–1; –6) | 45 (0) |
| B.0 | 100 mm | gypsum board [3 × 15 mm; without carpet] / 3-layer board [18 mm] | 531 mm | REI 60 | A2-s1,d0 | A2-s1,d0 | 46 (–8; –16) | 65 (–6) |
| B.1 | 100 mm | gypsum board [3 × 15 mm; with carpet; ΔLw > 25 dB] / 3-layer board [18 mm] | 531 mm | – | – | A2-s1,d0 | 46 (–8; –16) | 56 (0) |
| C.0 | 100 mm | gypsum board [3 × 15 mm; without carpet] / gypsum board [2 × 15 mm] | 536 mm | – | A2-s1,d0 | A2-s1,d0 | 58 (–2; –4) | 55 (–5) |
| C.1 | 100 mm | gypsum board [3 × 15 mm; with carpet; ΔLw > 25 dB] / gypsum board [2 × 15 mm] | 536 mm | – | – | A2-s1,d0 | 58 (–2; –4) | 50 (0) |

Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

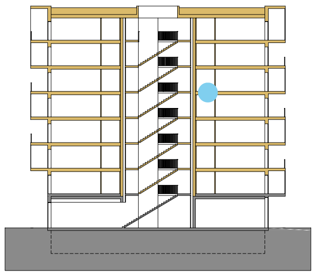
Sound isolation can be improved with different kinds of resilient channels.

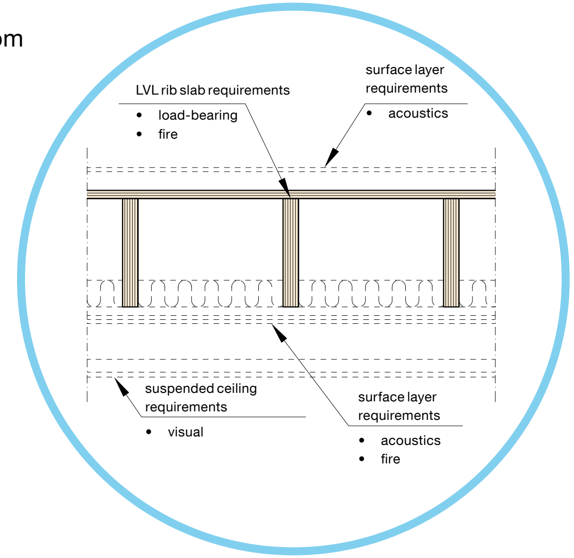
Manufacturer's installation instructions for resilient channels must be noted.

rethink.
storaenso

# VP 21

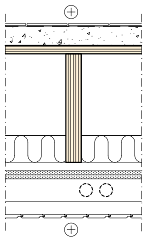
Rib slab intermediate floor, bathroom






## Variables

**A. Concrete slab, rib slab, suspended ceiling and panelling**



**Structure**

- tiles
- tile adhesive
- certified waterproofing system
- concrete slab [70 mm]
- PE-foil
- LVL rib slab** [435 mm] + insulation [100 mm]
- battening [32 mm]
- gypsum board [2 × 15 mm] (moisture protection in exposed surface)
- suspended ceiling and panelling (plumbing cavity)

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

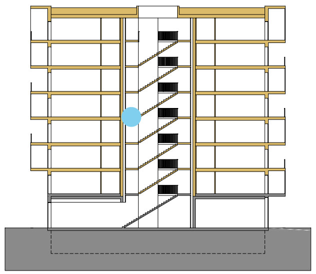
| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | | Rw (C; Ctr) [dB] | Ln,w (Ci) [dB] |
|---|---|---|---|---|---|---|---|---|
| | | | | | Floor | Ceiling | | |
| A.0 | 100 mm | tiles (without impact noise reduction matt) / gypsum boards [2 × 15 mm] | 726 mm | REI 60 | – | A2-s1,d0 | 52 (0; –2) | 65 (–4) |
| A.1 | 100 mm | tiles (with impact noise reduction matt under, ΔLw > 17 dB) / gypsum boards [2 × 15 mm] | 726 mm | REI 60 | – | A2-s1,d0 | 52 (0; –2) | 56–58 (0) |

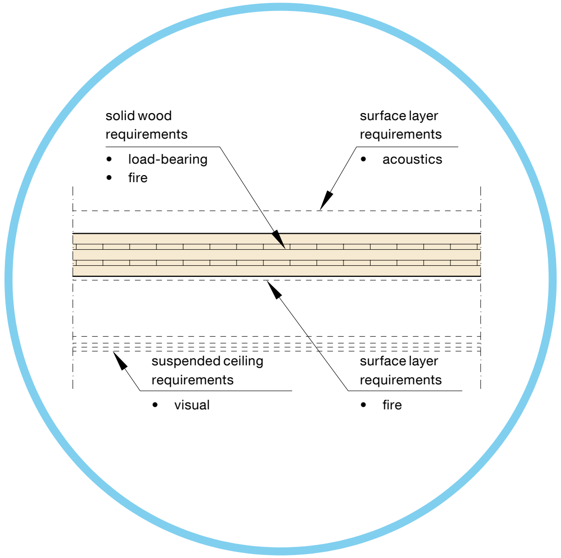
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics

# VP 31

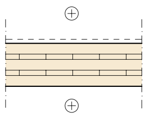
CLT slab intermediate floor, corridor





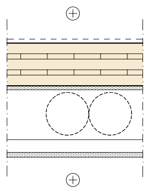

## Variables

### A. Surface layer, visual CLT



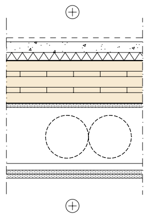
**Structure**
- surface layer
- CLT** [160 mm]
  (soft connection to the frame required)

### B. Surface layer, CLT, suspended ceiling



**Structure**
- surface layer
- CLT** [160 mm]
  (soft connection to the frame required)
- gypsum board [15 mm]
- suspended ceiling and gypsum board [18 mm]

### C. Floating floor, CLT, suspended ceiling, double gypsum boards



**Structure**
- floating screed slab [40 mm]
- filter cloth
- impact sound isolation [30 mm]
- CLT** [160 mm]
- gypsum board [15 mm]
- suspended ceiling
- resilient channel [25 mm]
- gypsum board [2 × 15 mm]

Note! In particular A.0 and B.0 have very high impact levels at low frequencies.

Charring calculated according to zero strength layer theory presented in EN 1995-1-2.
Charring is used for calculation of required CLT cross-section.

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | | Charring | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Floor | Ceiling | R60 | R90 |
| A.0 | – | CLT [without carpet] | 160 mm | – | – | D-s2, d0 | 46 mm | 84 mm |
| A.1 | – | CLT [with carpet; ΔLw > 25 dB] | 160 mm | – | – | D-s2, d0 | 46 mm | 84 mm |
| B.0 | – | CLT [without carpet] / gypsum board [18 mm] | 428 mm | – | – | A2-s1,d0 | – | – |
| B.1 | – | CLT [with carpet; ΔLw > 25 dB] / gypsum board [18 mm] | 428 mm | – | – | A2-s1,d0 | – | – |
| C.0 | 30 mm | floor slab [40 mm; without carpet] / gypsum boards [2 × 15 mm] | 510 mm | REI 60 | – | A2-s1,d0 | – | – |
| C.1 | 30 mm | floor slab [40 mm; with carpet; ΔLw > 25 dB] / gypsum boards [2 × 15 mm] | 510 mm | REI 60 | – | A2-s1,d0 | – | – |

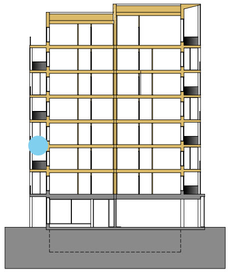
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

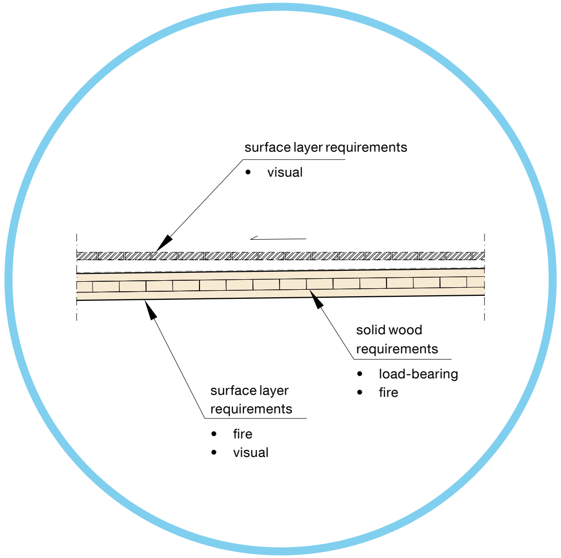
* variable
** according to structural calculations
*** air gap due to acoustics

Manufacturer's installation instructions for resilient channels must be noted.

# VP 4

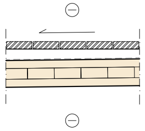
## CLT slab intermediate floor, balcony






## Variables

**A. Surface layer, visual CLT**



**Structure**
- open boarding [28 mm]
- doubling sleeper
- waterproofing
- CLT** [100 mm]
- fire-retardant treatment (optional)

Charring calculated according to zero strength layer theory presented in EN 1995-1-2.
Charring is used for calculation of required CLT cross-section.

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

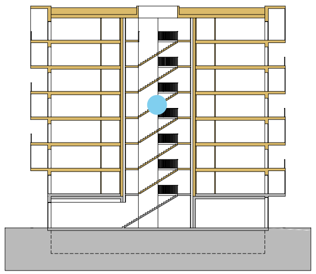
| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | | Charring | | Rw (C; Ctr) [dB] |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Floor | Ceiling | R60 | R90 | |
| A.0 | – | Boarding / fire-retardant treatment | 170 mm | REI 30 | – | B-s2.d0 | 55 mm | 94 mm | – |

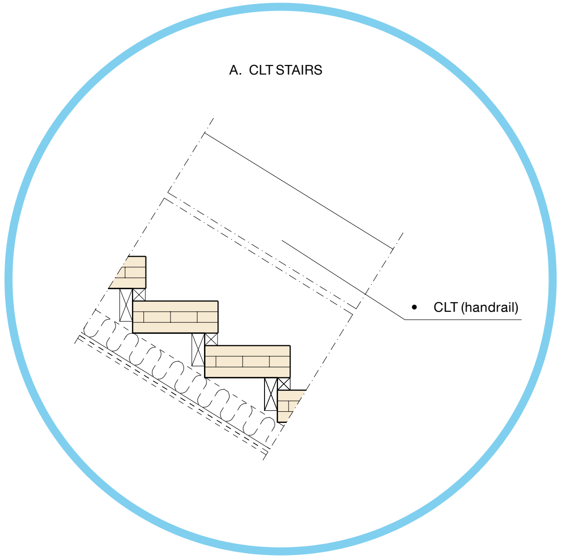
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics

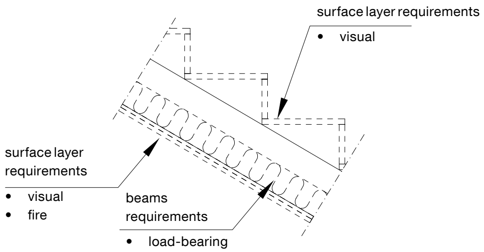
# VP 5

## Stairs



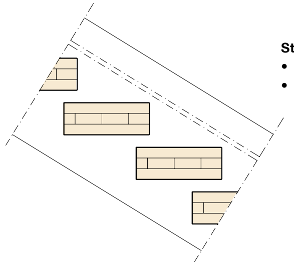



B. NAIL PLATE STRUCTURED STAIRS



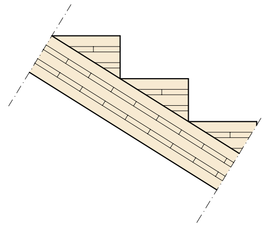

## Variables

### A. CLT stairs, load-bearing CLT handrails



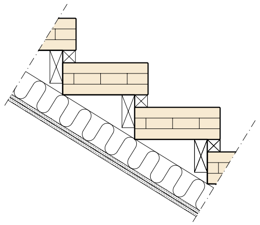
**Structure**
- CLT steps
- load-bearing CLT handrails

### B. CLT stairs, CLT slab



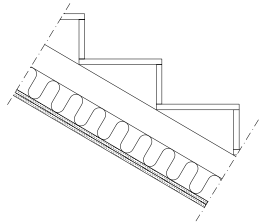
**Structure**
- CLT steps
- CLT slab**

### C. CLT steps, gluelam beams, insulation



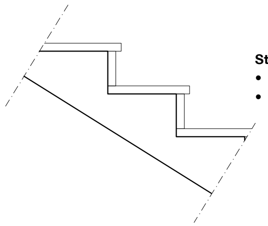
**Structure**
- CLT steps
- supporting beams for CLT steps and load-bearing CLT handrails**
- insulation [100 mm]
- gypsum board [2 × 13 mm]

### D. Plywood steps, nail plate connected beams, insulation



**Structure**
- plywood [21 mm]
- nail plate connected beams**
- insulation [100 mm]
- gypsum board [2 × 13 mm]

### E. Concrete stairs



**Structure**
- concrete steps
- concrete beams**

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | |
|---|---|---|---|---|---|---|
| | | | | | Floor | Ceiling |
| A.0 | 0 mm | CLT | – | – | – | D-s2, d0 |
| B.0 | 0 mm | CLT | 160 mm | – | – | D-s2, d0 |
| C.0 | 100 mm | CLT / gypsum board [2 × 13 mm] | 226 mm | REI 30 | DFL-s1 | A2-s1,d0 |
| D.0 | 100 mm | plywood / gypsum board [2 × 13 mm] | 198 mm | REI 30 | DFL-s1 | A2-s1,d0 |
| E.0 | 0 mm | concrete | 110 mm | – | – | – |

Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics

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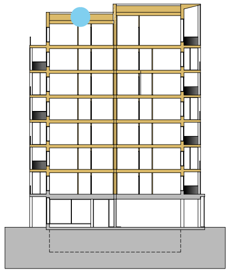
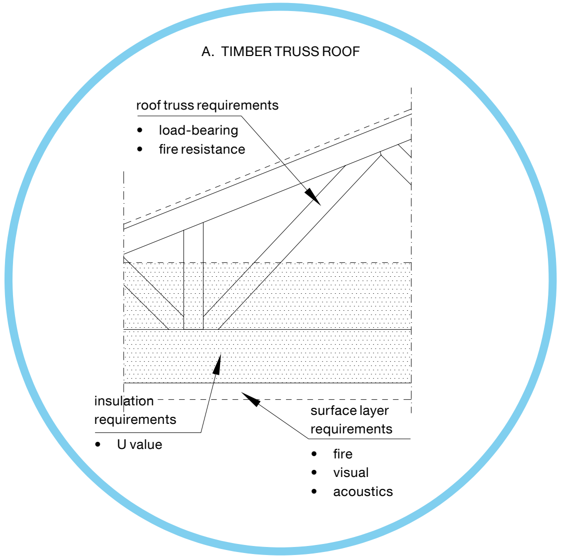
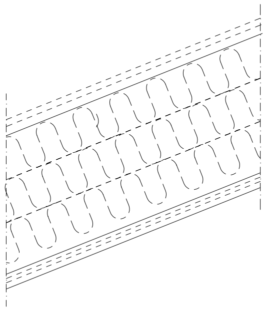
# YP 1

## Roof structure

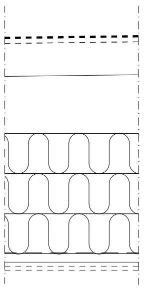





C. TIMBER BEAM ROOF

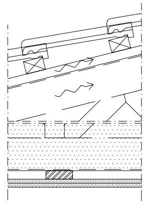


E. FLAT ROOF



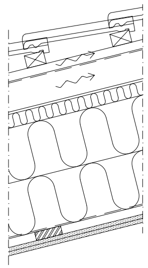
## Variables

### A. Timber truss roof



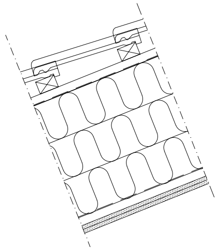
**Structure**
- roof material
- roof batten + ventilation batten
- roof underlayment
- roof truss with LVL-lower flange** + ventilation
- insulation [450 mm; rock wool]
- vapour barrier
- battening [32 mm]
- 2 gypsum boards [15 mm]

### B. Timber truss roof, LVL bottom chord



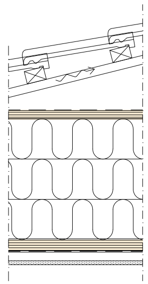
**Structure**
- roof material
- roof batten + ventilation batten
- roof underlayment
- roof truss** + ventilation [~100 mm]
- sheathing board [9 mm]
- insulation [450 mm; rock wool]
- vapour barrier
- battening [32 mm]
- 2 gypsum boards [15 mm]

### C. Timber beam roof



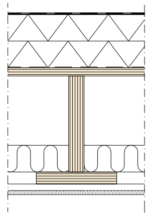
**Structure**
- roof material
- roof batten
- roof-covering sheeting
- LVL beam** [450 mm]
- insulation [450 mm; rock wool]
- hygroscopic membrane
- battening [32 mm]
- 2 gypsum boards [15 mm]

### D. LVL rib slab



**Structure**
- roofing tiles (sufficient pitch)
- roof batten + ventilation batten (ventilation cavity according to local climatic conditions)
- vapour barrier
- LVL rib slab + insulation [450 mm; rock wool]
- vapour barrier
- battening [32 mm]
- gypsum board [15 mm]

### E. LVL rib slab



**Structure**
- roof material
- rigid insulation [300 mm]
- vapour barrier
- LVL rib slab + insulation [rock wool] (thermal resistance of the air cavity and insulation shall be max. one third of total insulation of the structure)
- battening [32 mm]
- gypsum board [15 mm]

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

| Type | Insulation | Surface material | Thickness | Fire resistance | U [W/m²K] | Surface reaction to fire | | Rw (C; Ctr) [dB] |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Roof | Ceiling | |
| A.0 | 450 mm | gypsum boards [2 × 15 mm] | – | REI 60 | 0.087 | – | A2-s1,d0 | 57 (–1; –4) |
| B.0 | 450 mm | gypsum boards [2 × 15 mm] | – | REI 60 | 0.076 | – | A2-s1,d0 | 58 (–1; –5) |
| C.0 | 450 mm | gypsum boards [2 × 15 mm] | – | REI 60 | 0.077 | – | A2-s1,d0 | 58 (–1; –5) |
| D.0 | 450 mm | gypsum boards [15 mm] | – | REI 60 | 0.076 | – | A2-s1,d0 | 54 (–2; –3) |
| E.0 | 450 mm | gypsum boards [15 mm] | – | REI 60 | – | – | A2-s1,d0 | 56 (–1; –3) |

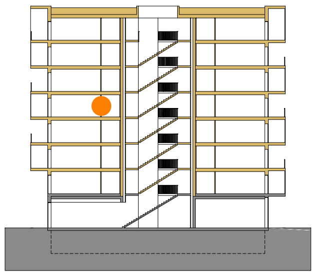
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

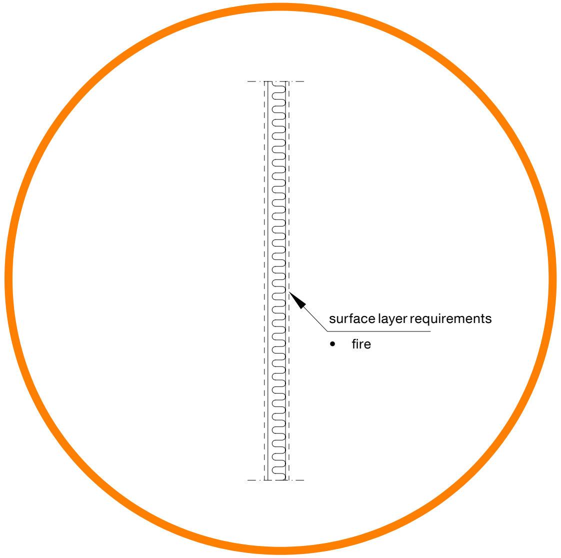
* variable
** according to structural calculations
*** air gap due to acoustics

Permeability and properties of the moisture barriers shall be according to local climatic conditions.

# VS 1

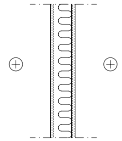
## Non-load-bearing partition wall





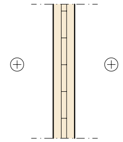

## Variables

**A. Timber or steel frame**



**Structure**
- gypsum board* [13 mm]
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- gypsum board* [13 mm]

**B. CLT**



**Structure**
- CLT [80 mm]

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

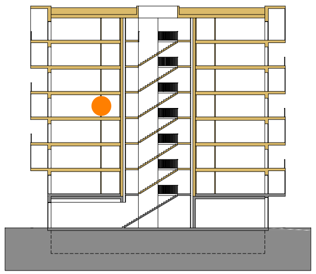
| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | Rw (C; Ctr) [dB] |
|---|---|---|---|---|---|---|
| A.0 | 50 mm | gypsum boards [13 mm] | 92 mm | EI 30 | A2-s1,d0 | 40 (–2; –8) |
| A.1 | 50 mm | wooden panel | 96 mm | – | D-s2, d0 | 40 (–2; –8) |
| B.0 | – | visible CLT | 80 mm | EI 60 | D-s2, d0 | 32 (–1; –3) |

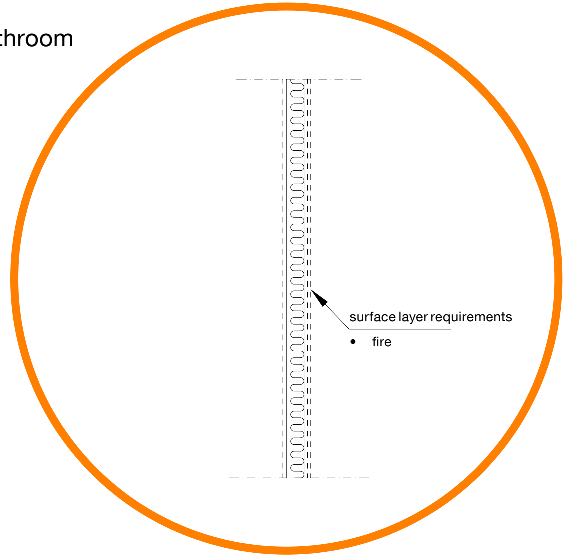
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics

# VS 2

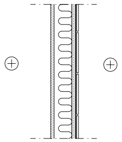
## Non-load-bearing partition wall, bathroom





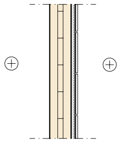

## Variables

### A. Timber or steel frame, bathroom



**Structure**
- gypsum board * [13 mm]
- timber (or steel) frame wall [66 mm] + insulation [50 mm]
- moisture resistant board [13 mm]
- certified waterproofing system
- tile adhesive
- tiles

### B. CLT, bathroom



**Structure**
- CLT [80 mm]
- moisture resistant board [13 mm]
- certified waterproofing system
- tile adhesive
- tiles

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

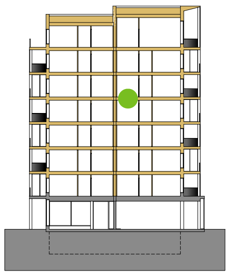
| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | Rw (C; Ctr) [dB] |
|---|---|---|---|---|---|---|
| A.0 | 50 mm | gypsum boards [13 mm] / tiles | 104 mm | EI30 | A2-s1,d0 / – | 46 (–1; –5) |
| A.1 | 50 mm | wood based panel / tiles | 106 mm | – | D-s2, d2 / – | 46 (–1; –5) |
| B.0 | – | visible CLT / tiles | 105 mm | EI60 | D-s2, d0 / – | 37 (–1; –3) |

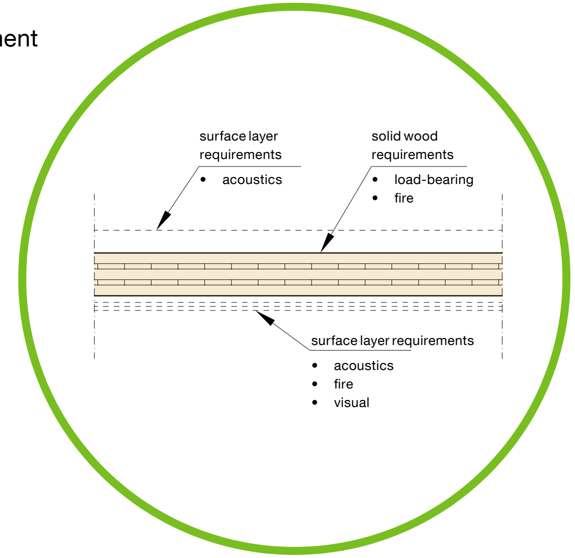
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics

# E-VP 12

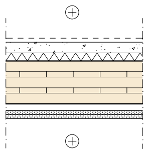
## CLT slab intermediate floor, apartment





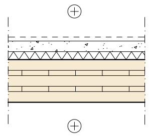

## Variables

**A. Floating floor slab, suspended ceiling**



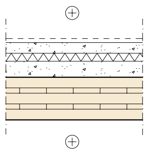
**Structure**
- floating floor slab [40 mm]
- impact sound isolation [30 mm]
- CLT** [160 mm]
- resilient channel [25 mm]
- gypsum board [2 × 15 mm]

**B. Floating floor slab, visual CLT**



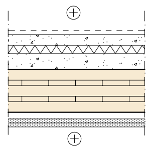
**Structure**
- floating floor slab [40* mm]
- impact sound isolation [30 mm]
- CLT** [160 mm]
  (soft connection to the frame required)
- visible CLT surface

**C. Floating floor slab, concrete-CLT composite, visual CLT**



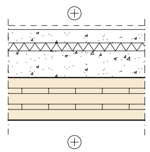
**Structure**
- floating floor slab [40 mm]
- filter cloth
- impact sound isolation [30 mm]
- concrete slab [60 mm]
- PE-foil
- CLT** [160 mm]
  (soft connection to the frame required)
- visible CLT surface

**D. Floating floor slab, concrete-CLT composite, suspended ceiling**



**Structure**
- floating floor slab [40 mm]
- filter cloth
- impact sound isolation [30 mm]
- concrete slab [60 mm]
- PE-foil
- CLT** [160 mm]
- resilient channel [25 mm]
- gypsum board [2 × 15 mm]

**E. Floating floor slab, chippings (gravel), visual CLT**



**Structure**
- floating floor slab [50 mm]
- filter cloth
- impact sound isolation [30 mm]
- chippings [100 mm]; ρ > 1,400 kg/m³
- PE-foil
- CLT** [140 mm]
  (soft connection to the frame required)
- visible CLT surface

Charring calculated according to zero strength layer theory presented in EN 1995-1-2.
Charring is used for calculation of required CLT cross-section.

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | | Charring | | Rw (C; Ctr) [dB] | Ln,w (Ci) [dB] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Floor | Ceiling | R60 | R90 | | |
| A.0 | 30 mm | floor slab [40 mm] / gypsum boards [2 × 15 mm] | 285 mm | REI 60 | – | A2-s1,d0 | – | – | 55 (–3; –6) | 50 (9) |
| B.0 | 30 mm | floor slab [40 mm] / CLT | 230 mm | – | – | D-s2, d0 | 46 mm | 84 mm | 43 (0; –4) | 72 (–10) |
| B.1 | 30 mm | floor slab [80 mm] / CLT | 270 mm | – | – | D-s2, d0 | 46 mm | 84 mm | 48 (0; –2) | 70 (–10) |
| C.0 | 30 mm | floor slab [40 mm] / CLT | 290 mm | – | – | D-s2, d0 | 46 mm | 84 mm | 52 (–1; –4) | 58 (0) |
| D.0 | 30 mm | floor slab [40 mm] / gypsum boards [2 × 15 mm] | 345 mm | – | – | A2-s1,d0 | – | – | 58 (–1; –6) | 48 (–7) |
| E.0 | 30 mm | floor slab [50 mm] / CLT | 340 mm | – | – | D-s2, d0 | 46 mm | 84 mm | 65 (–2; –5) | 53 (–1) |

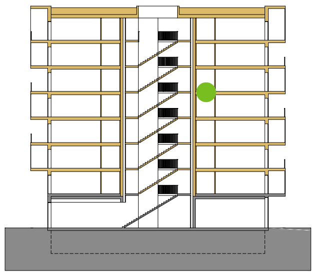
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

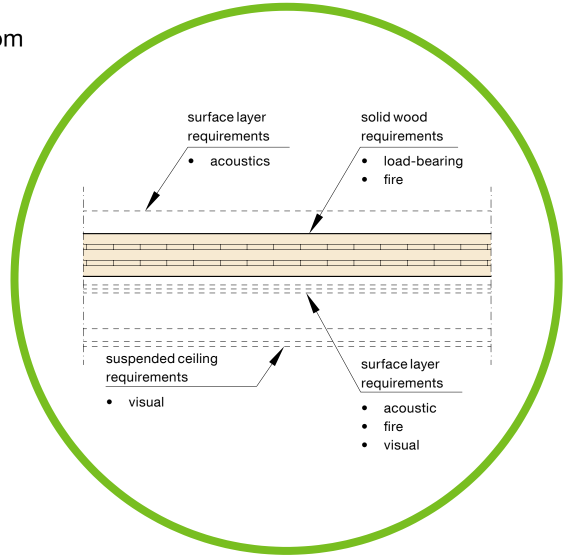
* variable
** according to structural calculations
*** air gap due to acoustics

Manufacturer's installation instructions for resilient channels must be noted

# E-VP 22

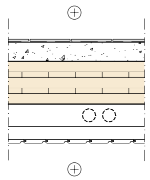
## CLT slab intermediate floor, bathroom





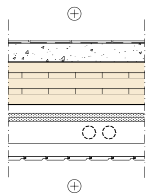

## Variables

**A. Concrete slab, CLT, suspended ceiling and panelling**



**Structure**
- tiles
- tile adhesive
- certified waterproofing system
- concrete slab [70 mm]
- PE-foil
- CLT** [160 mm]
- suspended ceiling and panelling (plumbing cavity)

**B. Concrete slab, CLT, gypsum boards, suspended ceiling and panelling**



**Structure**
- tiles
- tile adhesive
- certified waterproofing system
- concrete slab [70 mm]
- PE-foil
- CLT** [160 mm]
- battening [32 mm]
- gypsum board [2 × 15 mm] (moisture protection in exposed surface)
- suspended ceiling and panelling (plumbing cavity)

Charring calculated according to zero strength layer theory presented in EN 1995-1-2.
Charring is used for calculation of required CLT cross-section.

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

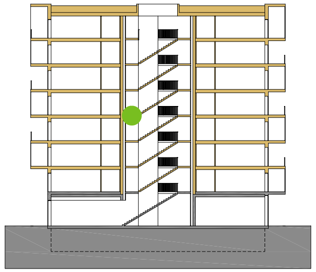
| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | | Charring | | Rw (C; Ctr) [dB] | Ln,w (Ci) [dB] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Floor | Ceiling | R60 | R90 | | |
| A.0 | 30 mm | tiles / CLT | 388 mm | – | – | D-s2, d0 | 46 mm | 84 mm | 50 (–4; –11) | 70 (–6) |
| B.0 | 30 mm | tiles / gypsum boards [2 × 15 mm] | 450 mm | REI 60 | – | A2-s1,d0 | – | – | 52 (0; –2) | 65 (–4) |

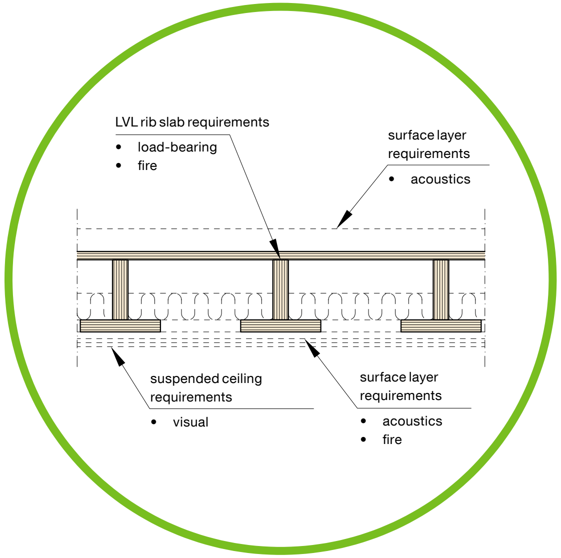
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations
*** air gap due to acoustics

# E-VP 32

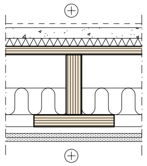
## Rib slab intermediate floor, corridor






## Variables

**A. Floating floor, rib slab, suspended ceiling, double gypsum boards**



**Structure**
- floating screed slab [40 mm]
- filter cloth
- impact sound isolation [30 mm]
- LVL rib slab** [300 mm] + insulation [100 mm]
- resilient channel [25 mm]
- gypsum board [2 × 15 mm]

Variables of the construction materials, listed from the outside to the inside. Yellow colour indicates changed variable.

| Type | Insulation | Surface material | Thickness | Fire resistance | Surface reaction to fire | | Rw (C; Ctr) [dB] | Ln,w (Ci) [dB] |
|---|---|---|---|---|---|---|---|---|
| | | | | | Floor | Ceiling | | |
| A.0 | 130 mm | floor slab [40 mm] / gypsum boards [2 × 15 mm] | 426 mm | REI 60 | – | A2-s1,d0 | 58 (–1; –6) | 51 (0) |

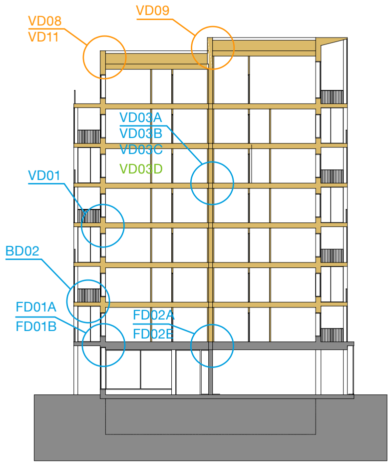
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

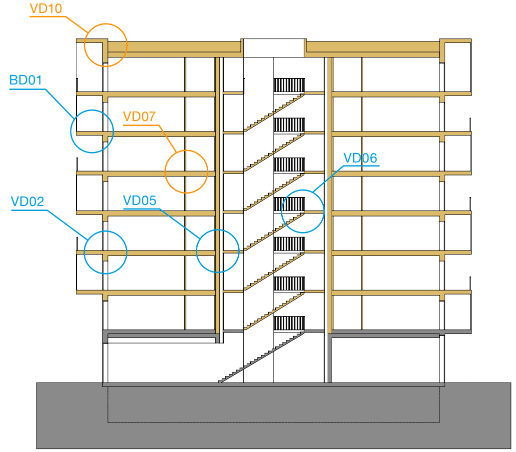
* variable
** according to structural calculations
*** air gap due to acoustics

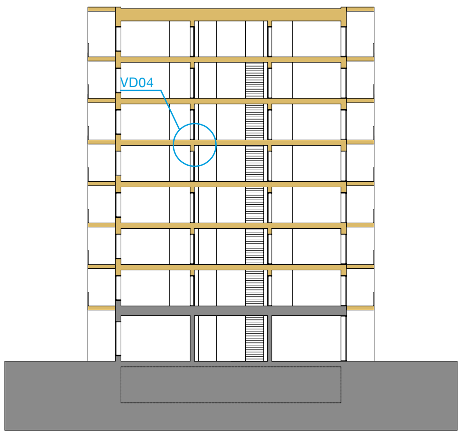
Manufacturer's installation instructions for resilient channels must be noted.

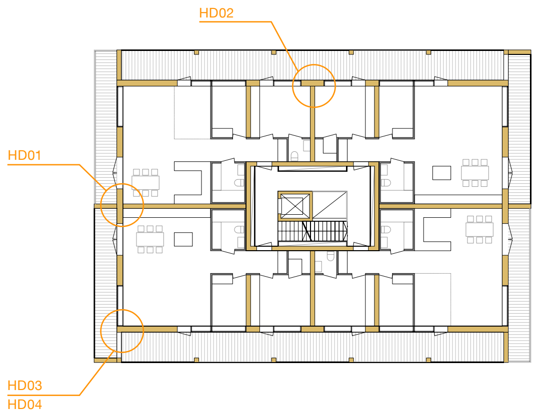
# 5.2 Structural details

## Orientation Chart



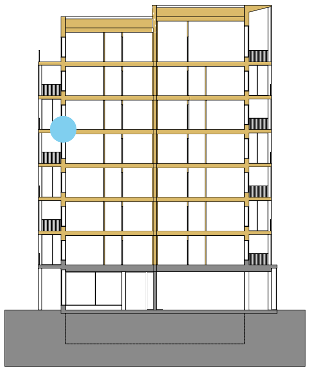



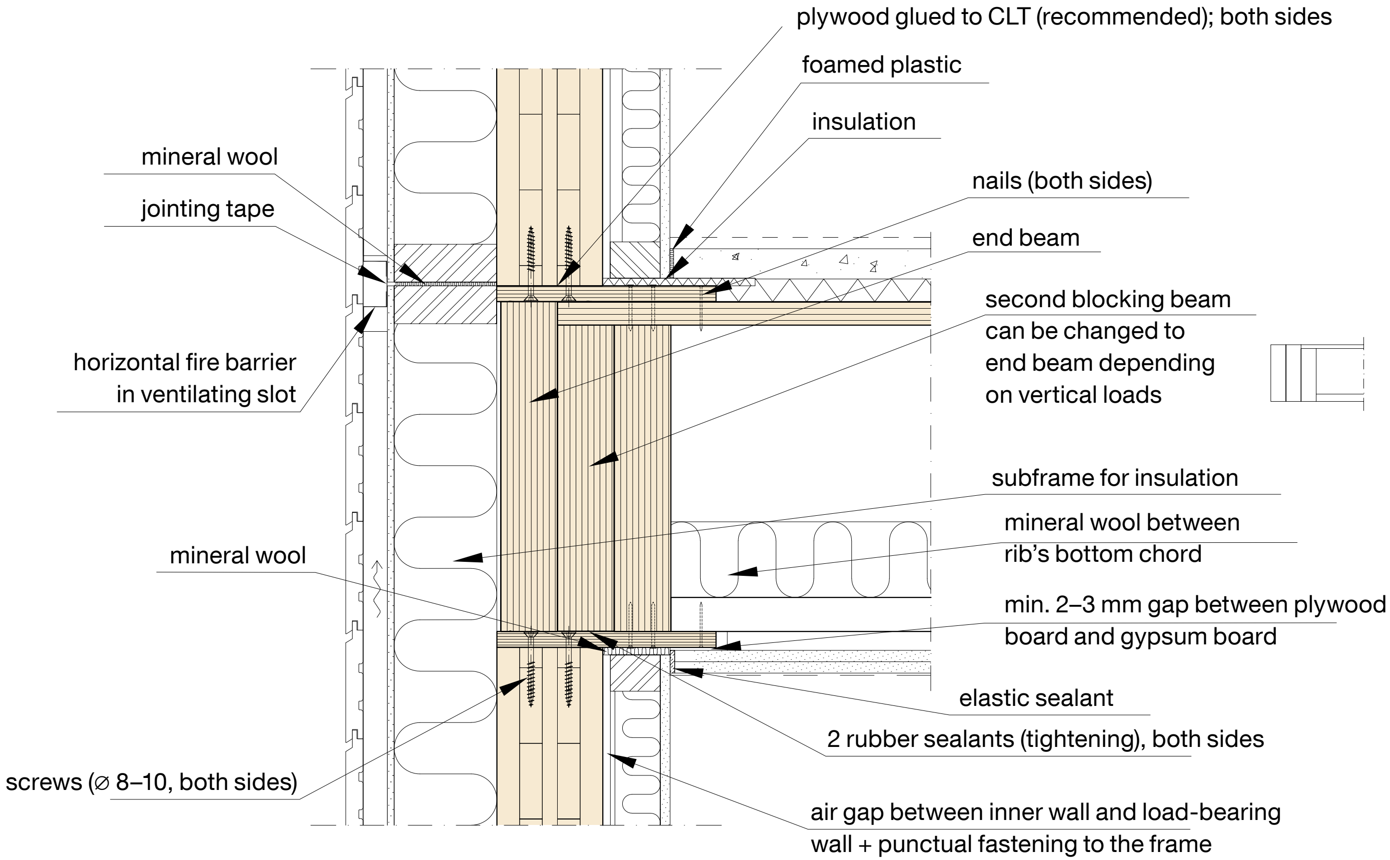
# List of Drawings

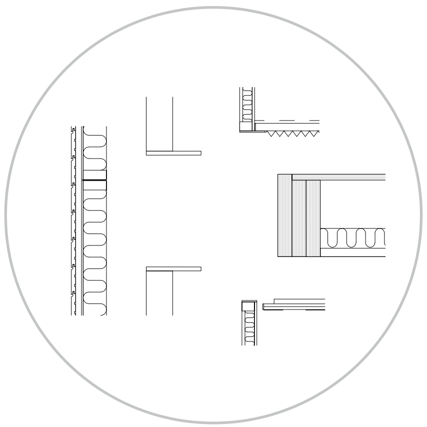
| Detail name | No. | | Description | Note |
|---|---|---|---|---|
| VD | 1 | | Intermediate floor to load-bearing external wall, apartment | |
| VD | 2 | | Intermediate floor to external wall, apartment | |
| | | | Installation of non-load-bearing external wall | |
| VD | 3 | A | Intermediate floor to load-bearing partition wall, apartment | |
| | | B | Uplift tie, shear transfer | |
| | | C | Intermediate floor to load-bearing partition wall, bathroom | |
| | | D | Intermediate floor to load-bearing partition wall, apartment | Extension |
| VD | 4 | | Intermediate floor to load-bearing partition wall, corridor | |
| VD | 5 | | Intermediate floor to non-load-bearing partition wall, corridor, ducts | |
| VD | 6 | | Stairs to intermediate floor, corridor | |
| VD | 7 | | Intermediate floor to non-load-bearing partition wall, apartment | |
| VD | 8 | | Roof to load-bearing external wall | |
| VD | 9 | | Roof to non-load-bearing partition wall | |
| VD | 10 | | Roof to non-load-bearing external wall | |
| VD | 11 | | Roof to load-bearing external wall | Extension |
| VD | 12 | | Intermediate floor to load-bearing partition wall, apartment (low rise building) | Extension |
| VD | 13 | | Intermediate wall to load-bearing partition wall, apartment (12 floors) | Extension |
| VD | 14 | | Intermediate floor to concrete wall, apartment | |
| FD | 1 | A | External wall base detail, fastening | |
| | | B | External wall base detail, shear transfer | |
| FD | 2 | A | Load-bearing partition wall, base detail, uplift tie | |
| | | B | Load-bearing partition wall, base detail, shear transfer and uplift tie | |
| HD | 1 | | T-connection at external wall, non-load-bearing and load-bearing walls | |
| HD | 2 | | T-connection at external wall, load-bearing walls | |
| HD | 3 | | Outer corner, load-bearing and non load-bearing walls | |
| HD | 4 | | Outer corner, load-bearing walls | |
| HD | 5 | | Re-entering corner | |
| BD | 1 | | Balcony detail, non-load-bearing wall | |
| BD | 2 | | Balcony detail, load-bearing wall | |

# VD 1

Intermediate floor to load-bearing external wall, apartment





Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

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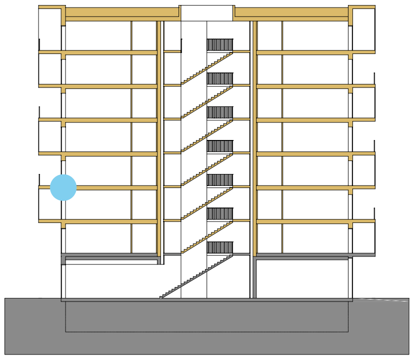
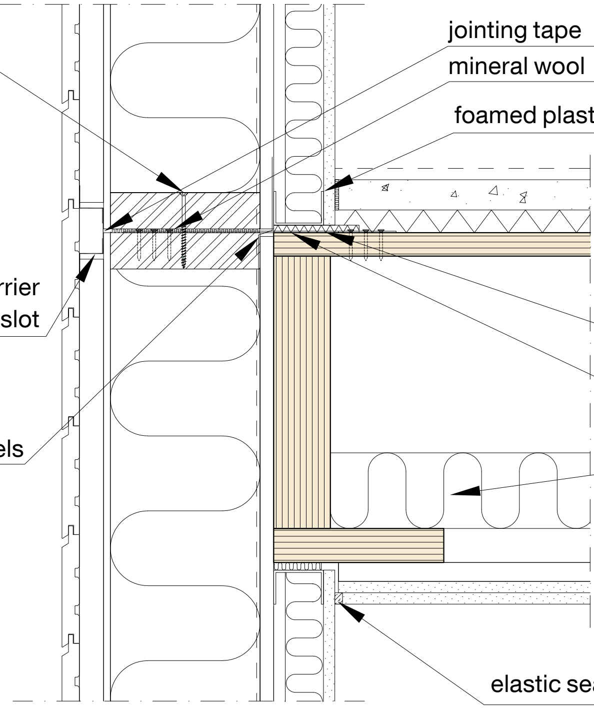
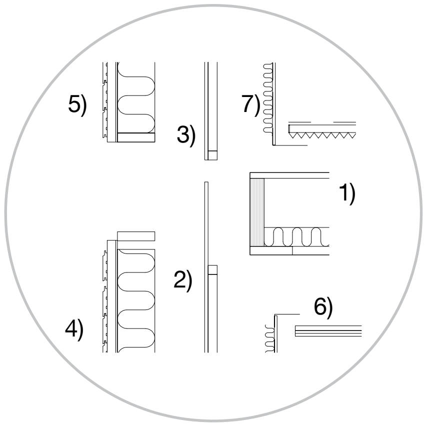
# VD 2

Intermediate floor to external wall, apartment



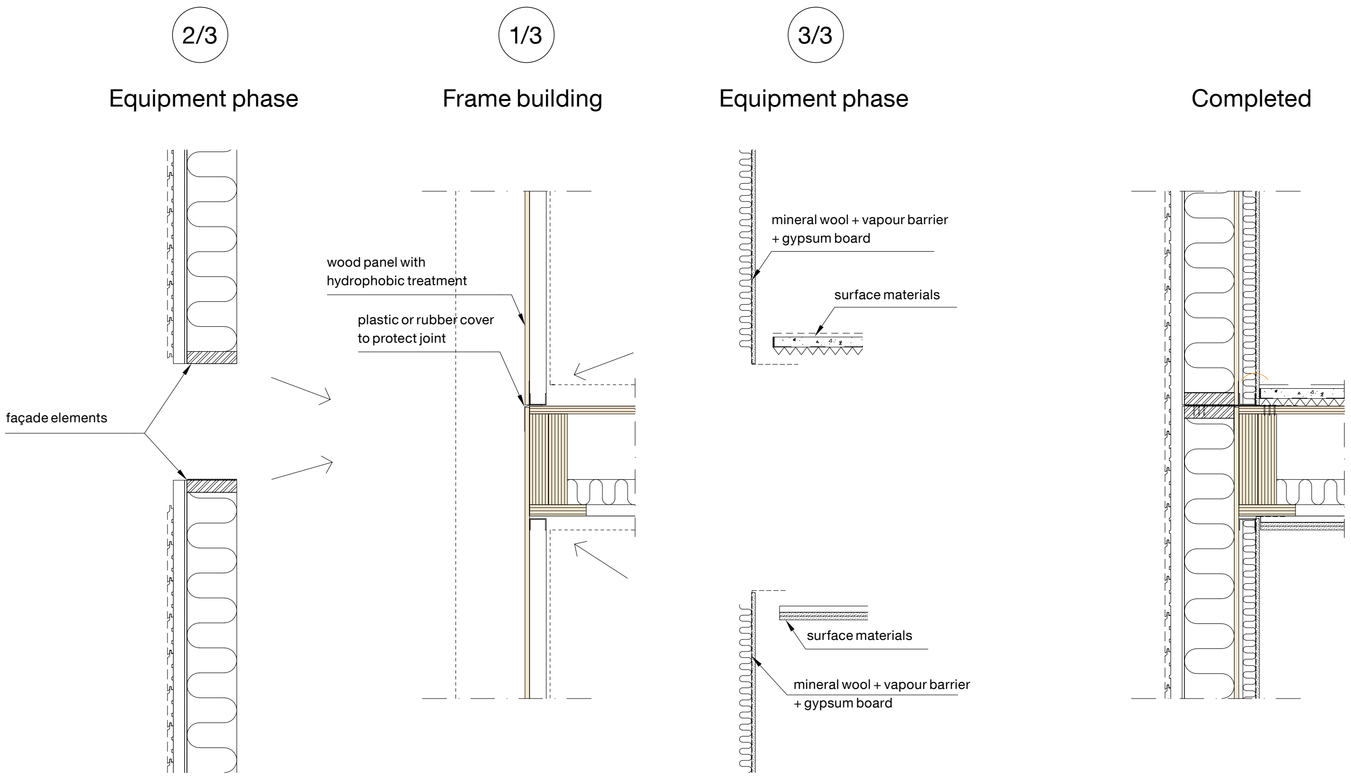


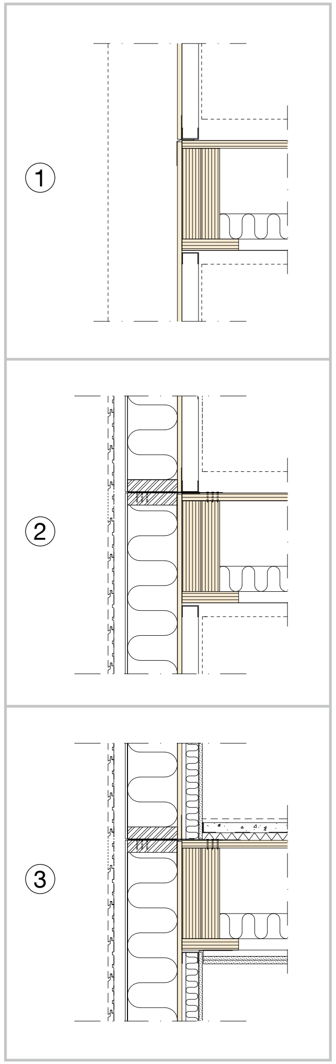




Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# VD 2

Installation of non-load-bearing external wall

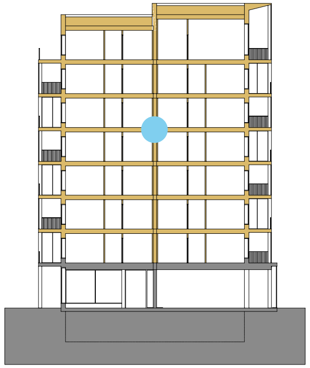


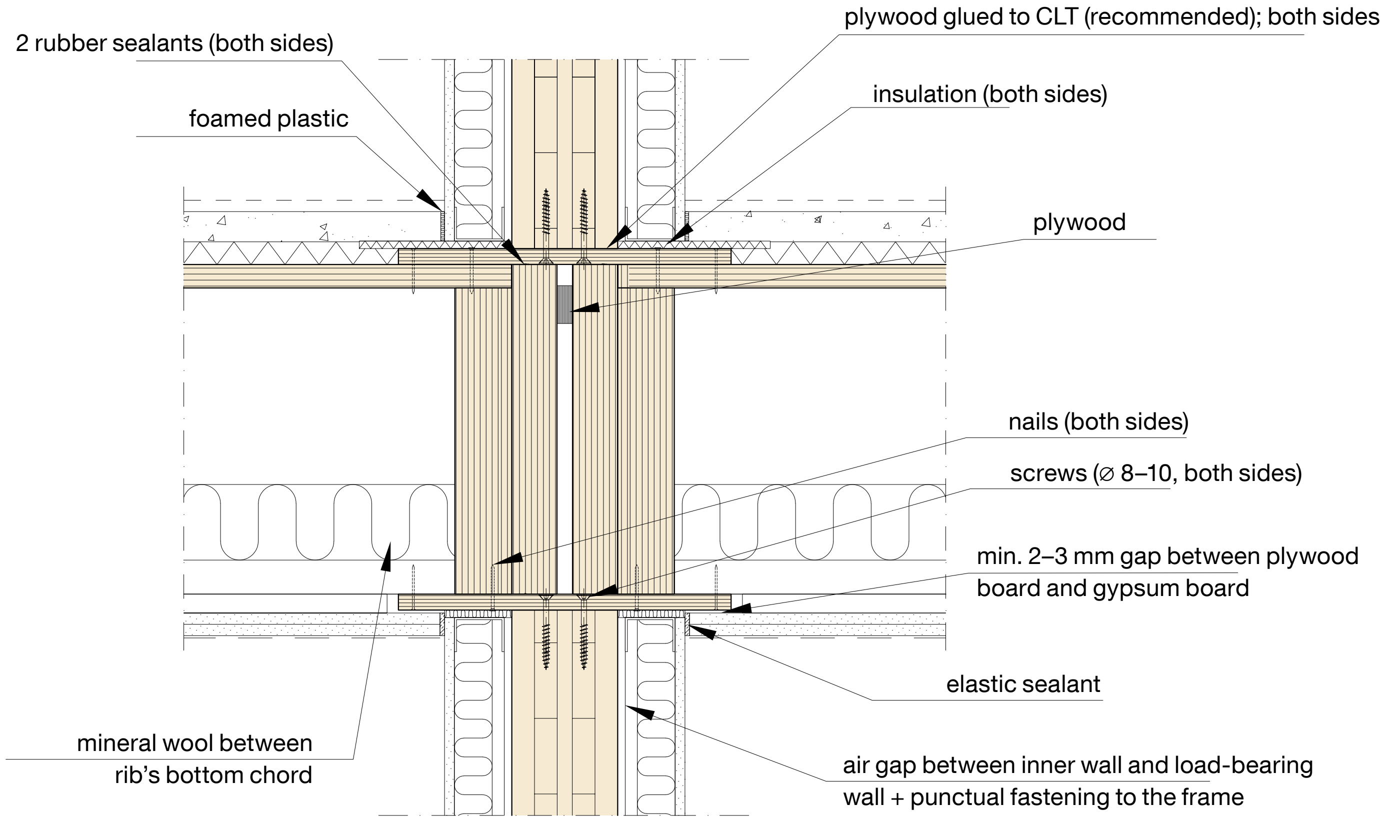



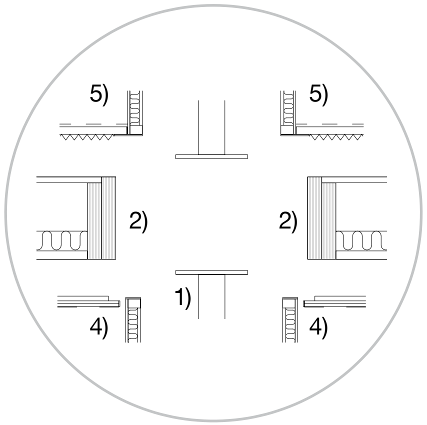

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# VD 3 A

Intermediate floor to load-bearing partition wall, apartment



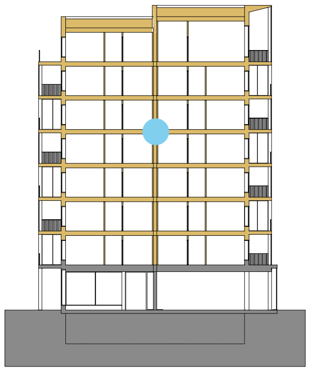


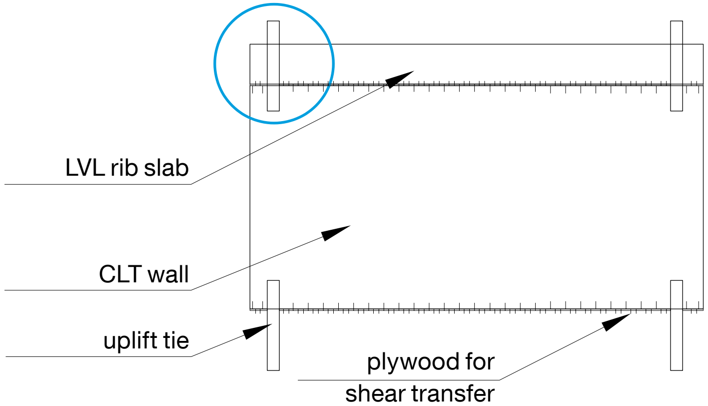



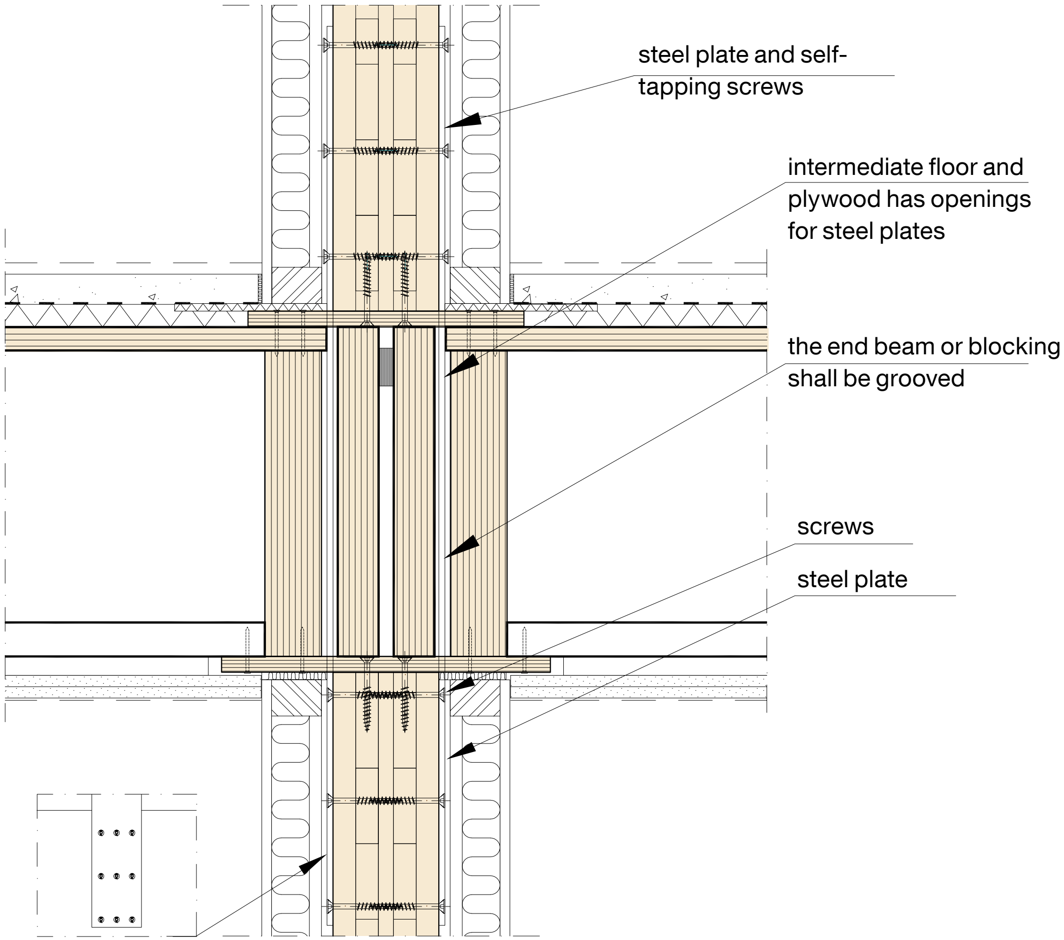

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# VD 3 B

Uplift tie, shear transfer



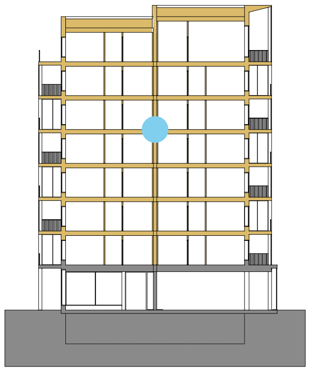


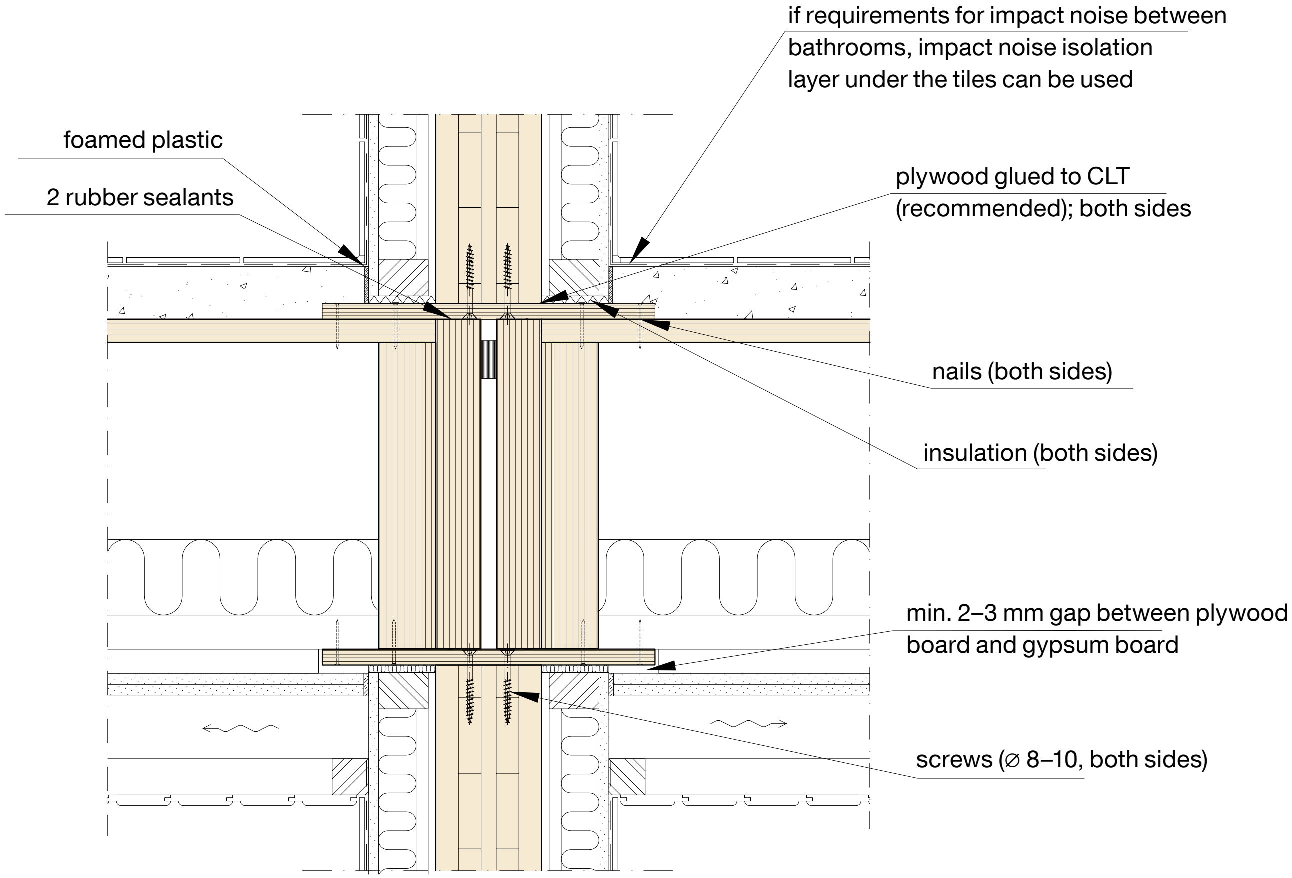



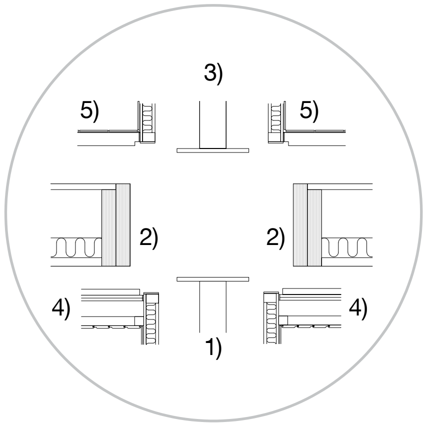

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# VD 3 C

Intermediate floor to load-bearing partition wall, bathroom



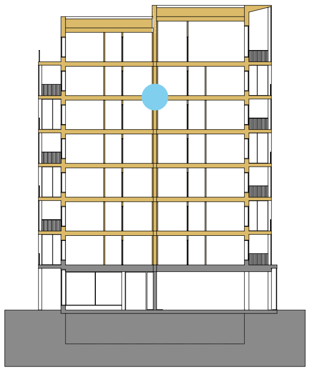


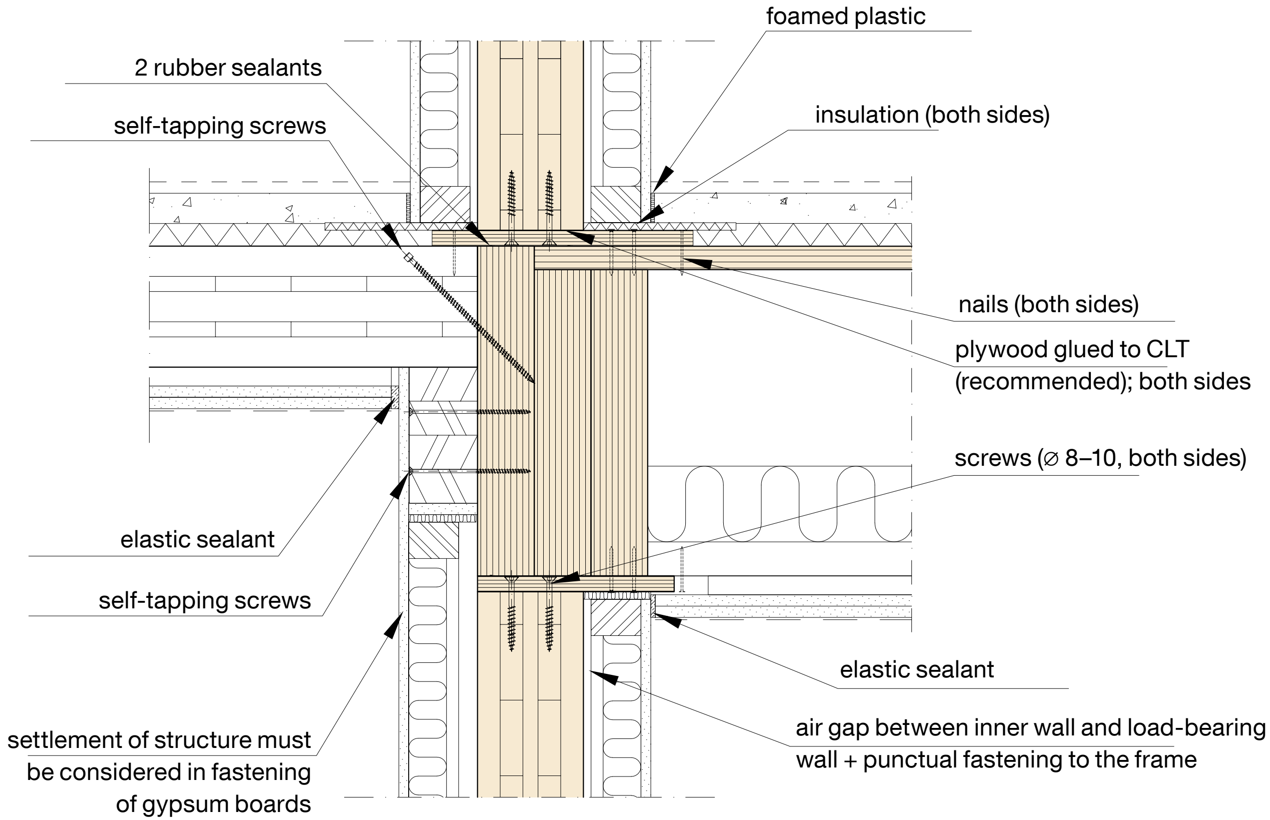



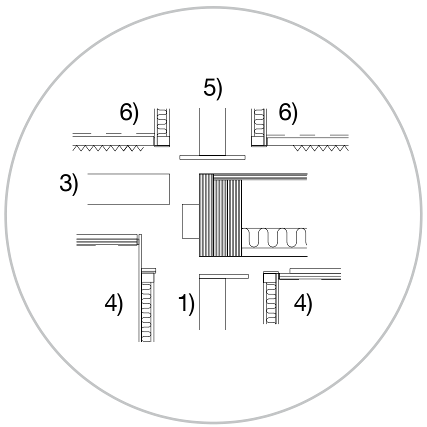

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# VD 3 D

Intermediate floor to load-bearing partition wall, apartment






Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

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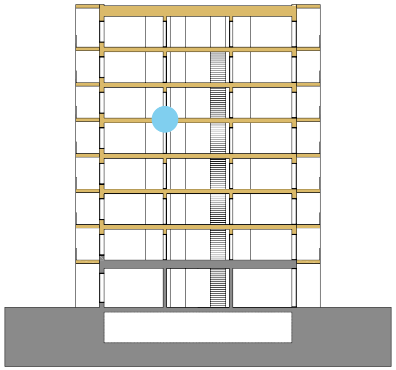
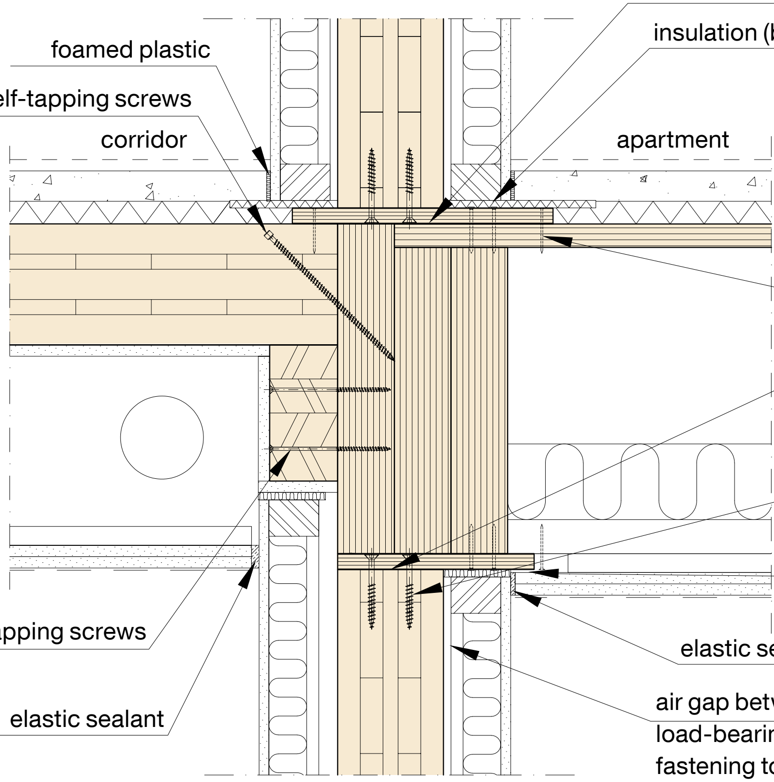
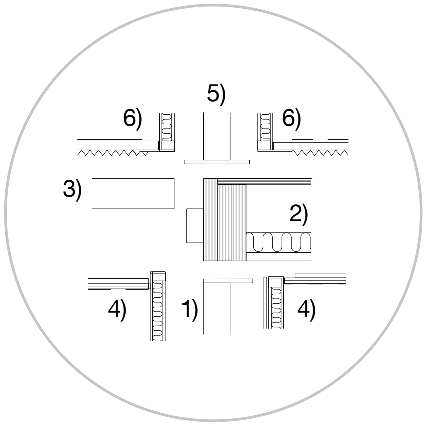
# VD 4

Intermediate floor to load-bearing partition wall, corridor



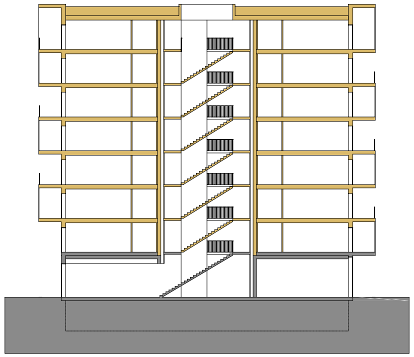


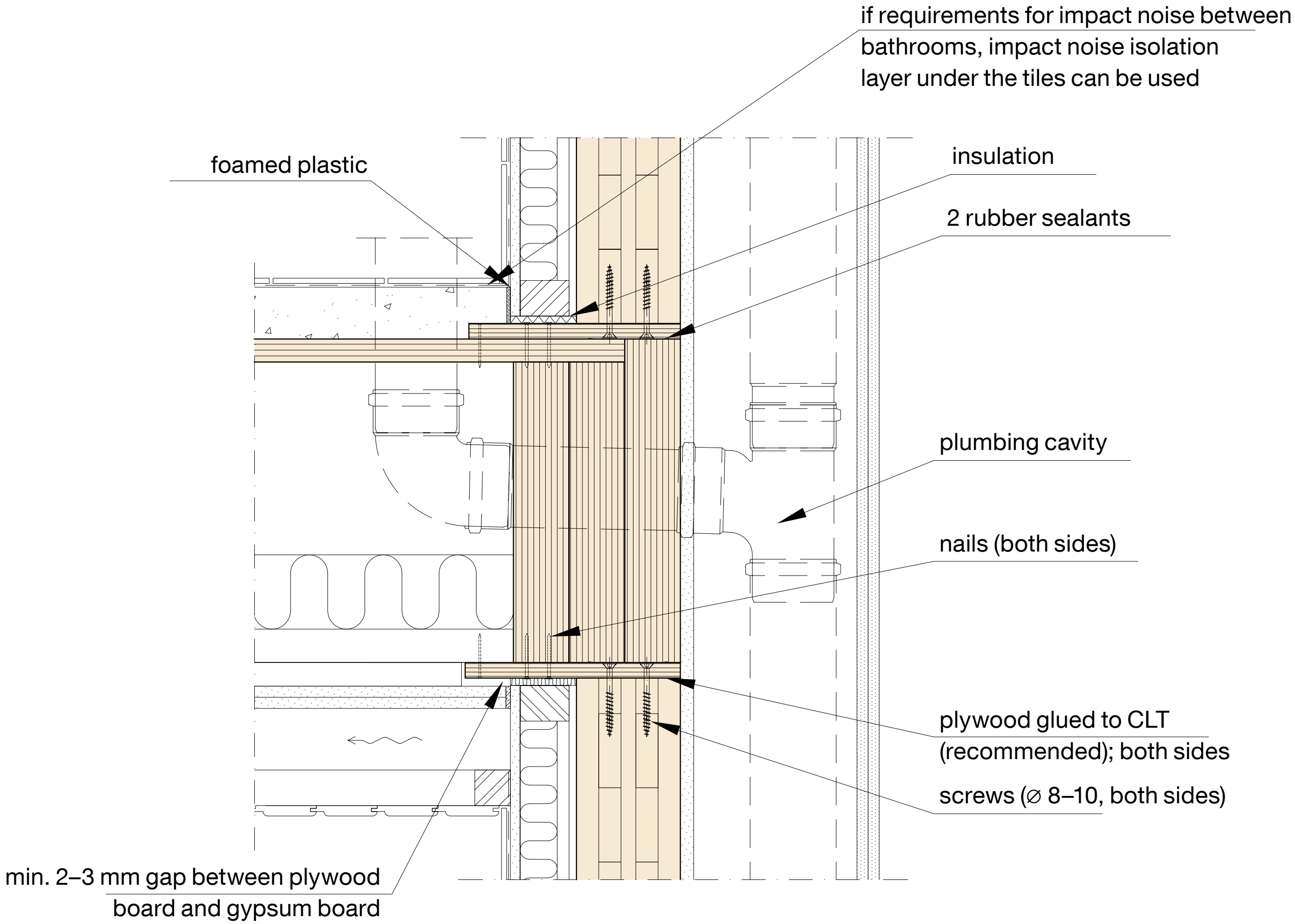



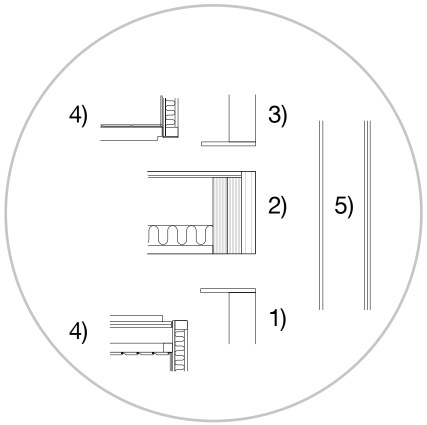

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# VD 5

Intermediate floor to load-bearing partition wall, corridor, ducts






Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

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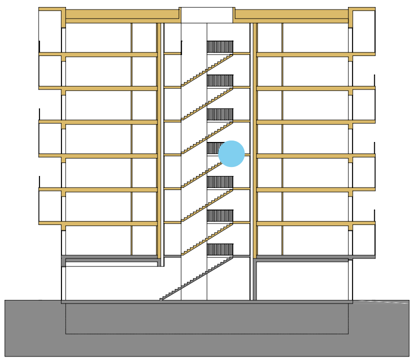
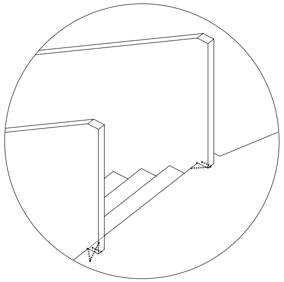
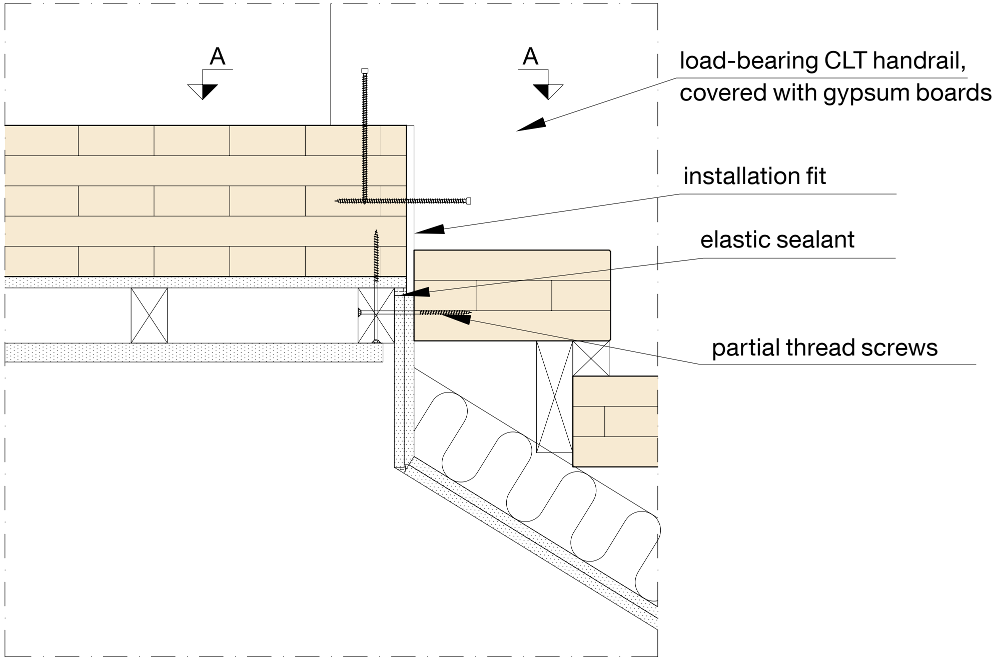
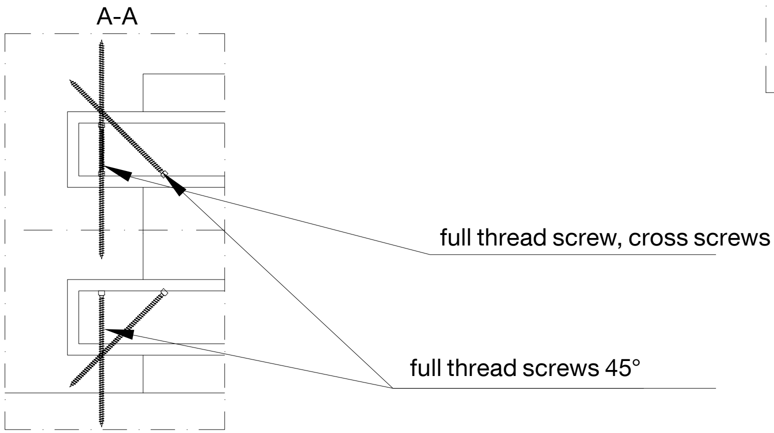
# VD 6

Stairs to intermediate floor, corridor





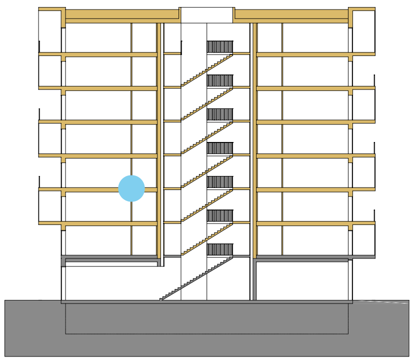


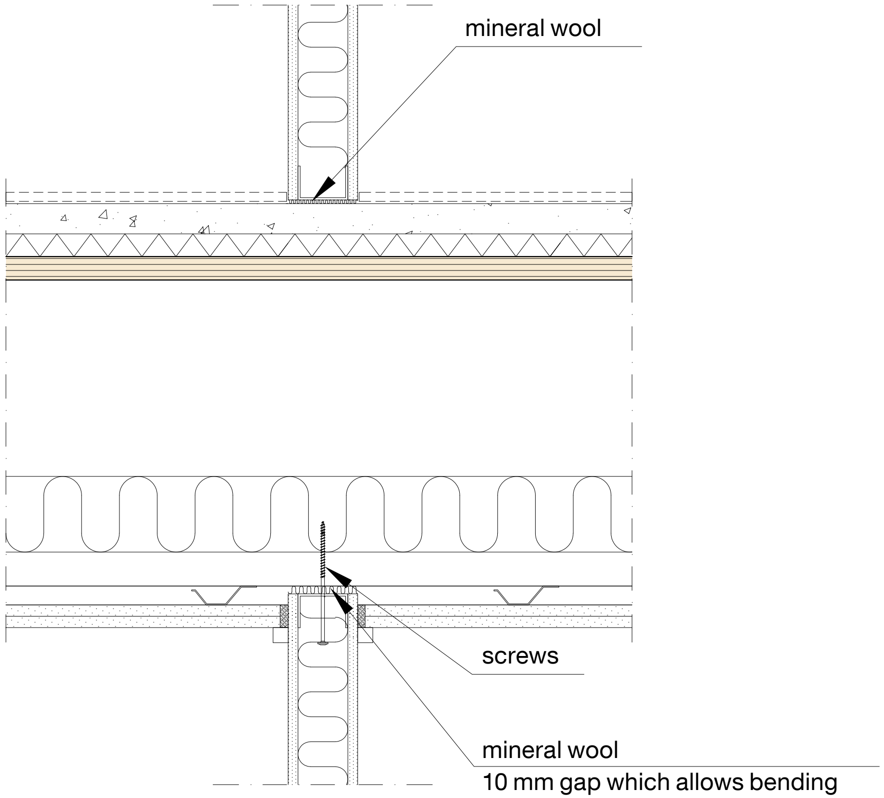



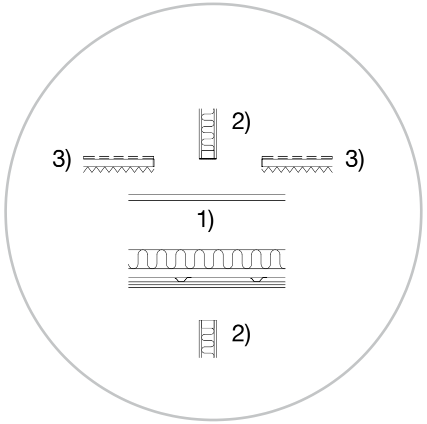

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# VD 7

Intermediate floor to non-load-bearing partition wall, apartment



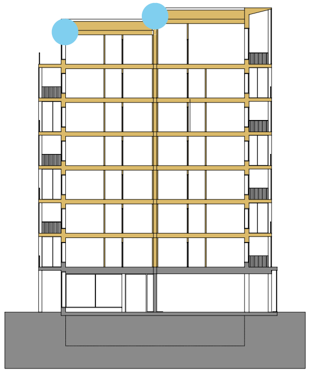


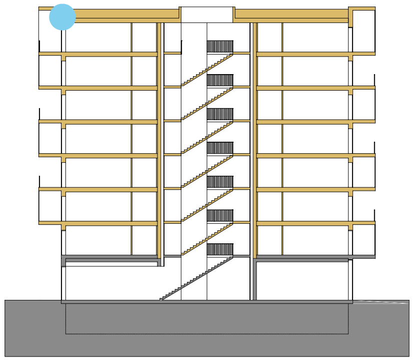




Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

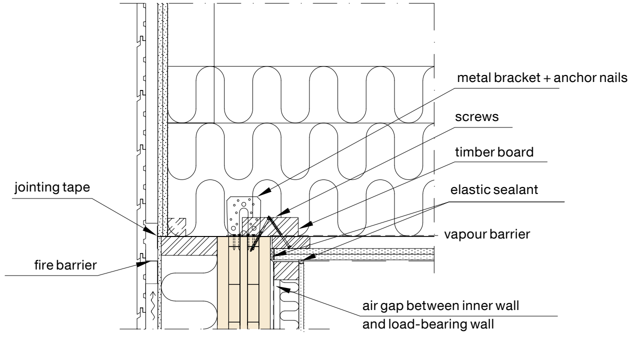
# VD 08-11

Roof details

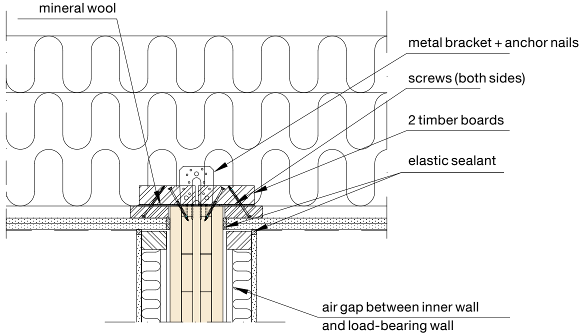




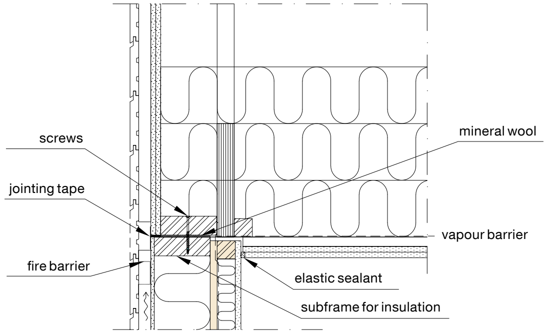
VD08 Roof to load-bearing external wall



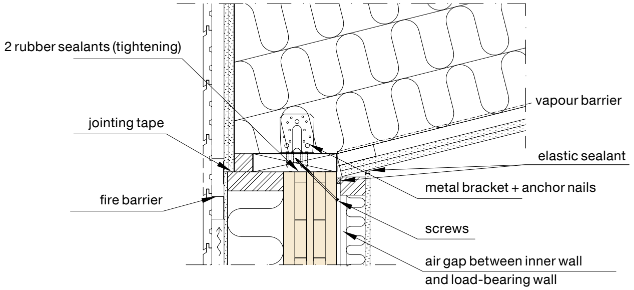

VD09 Roof to load-bearing partition wall




VD10 Roof to non-load-bearing external wall



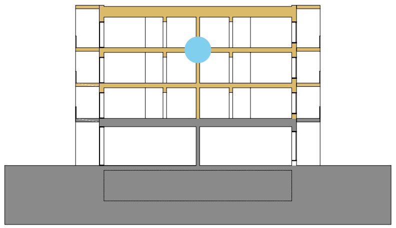

VD11 Roof to load-bearing external wall

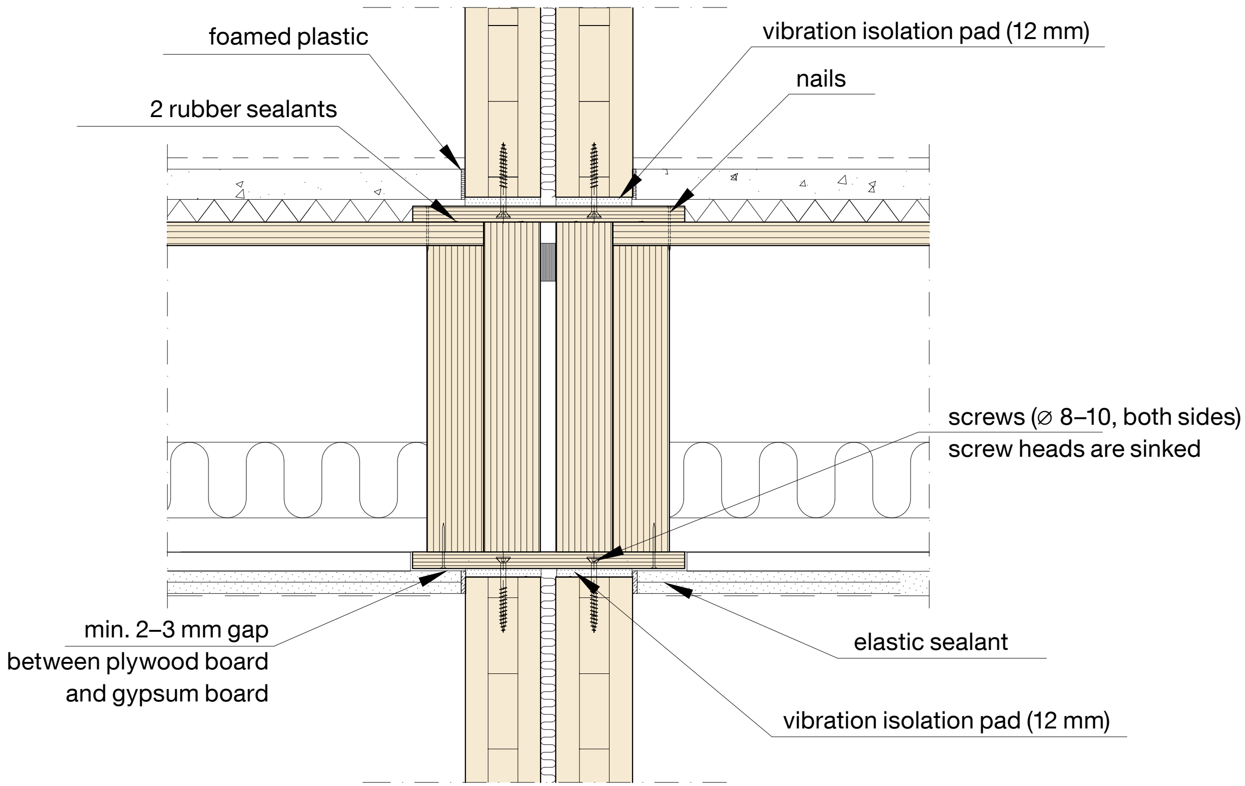


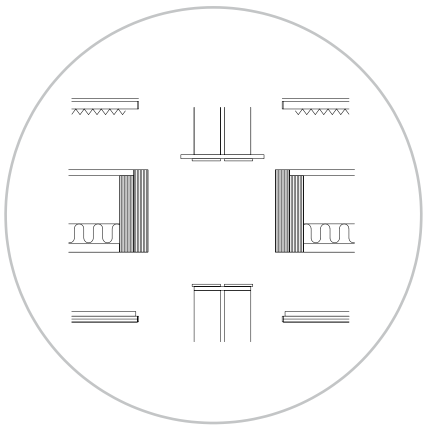

To ensure sufficient sound isolation, resilient channel can be used.
Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# VD 12

Intermediate floor to load-bearing partition wall, apartment (low rise building)



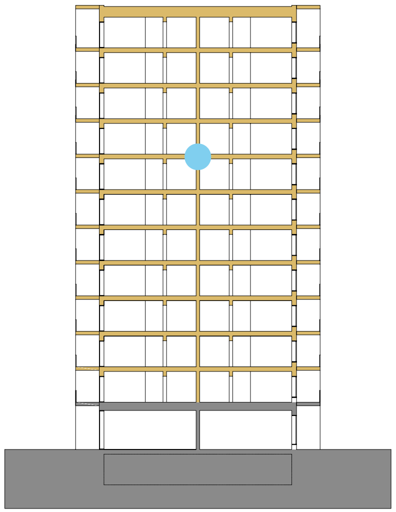


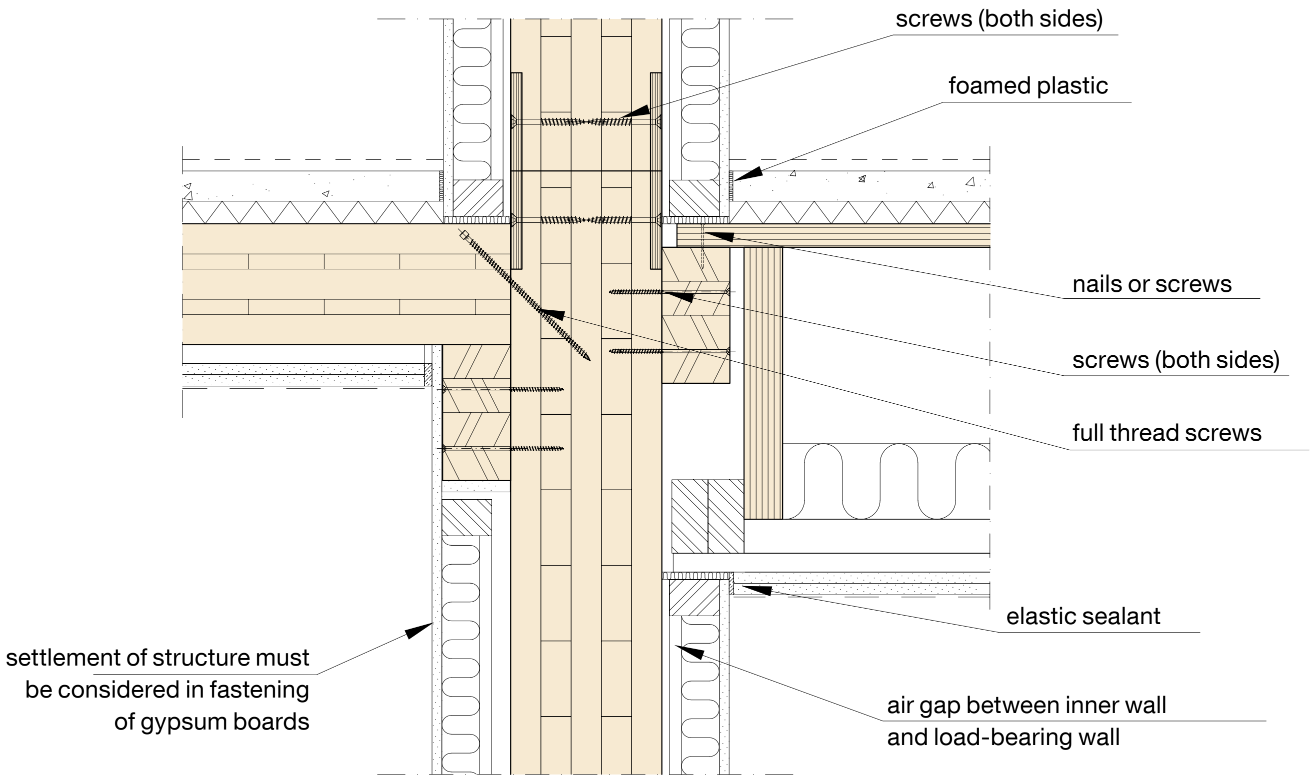



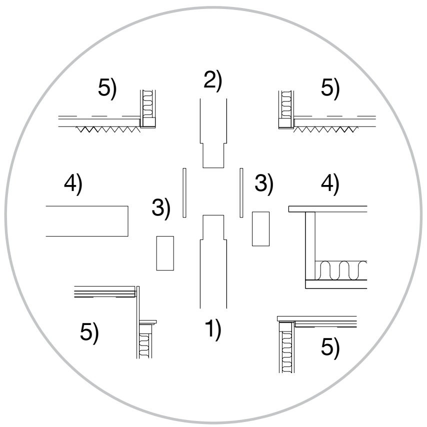
Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# VD 13

Intermediate wall to load-bearing partition wall, apartment (12 floors)



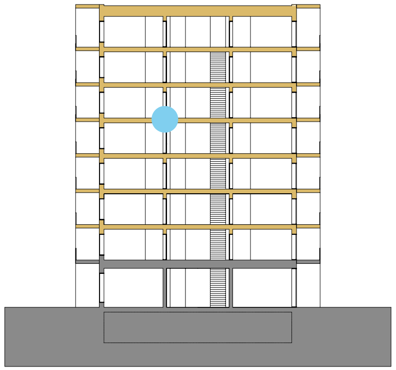


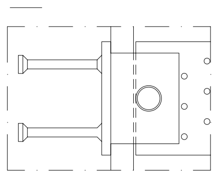



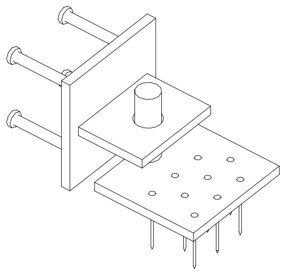

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

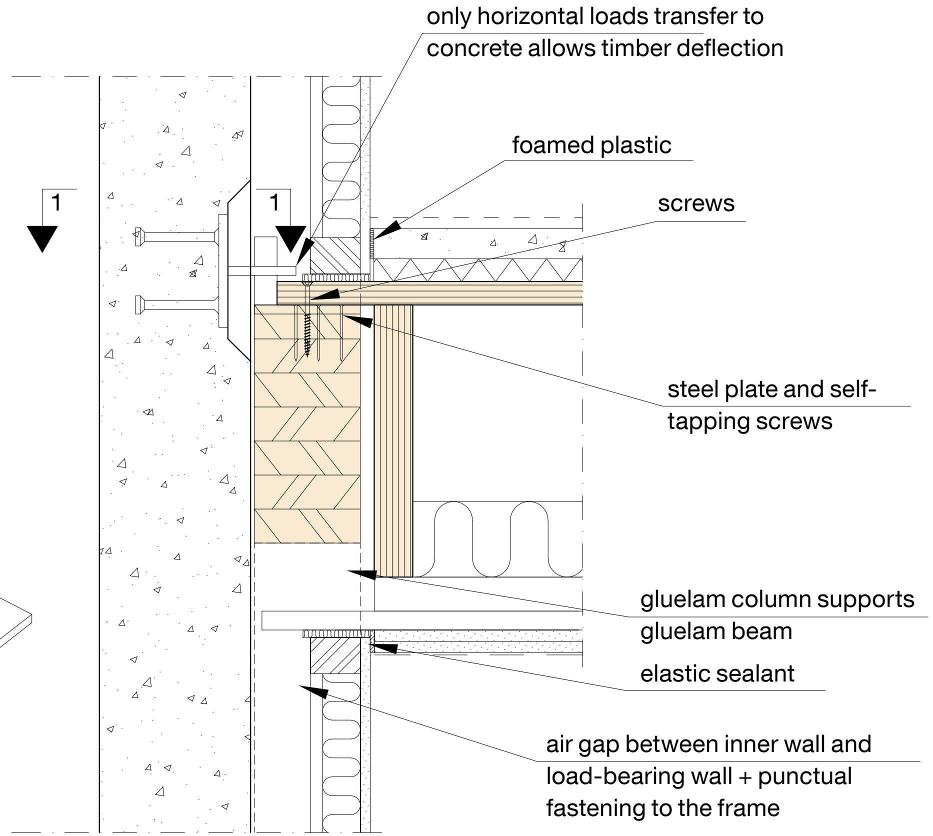
# VD 14

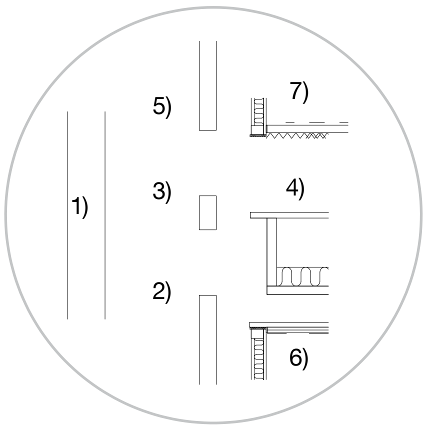
Intermediate floor to concrete wall, apartment







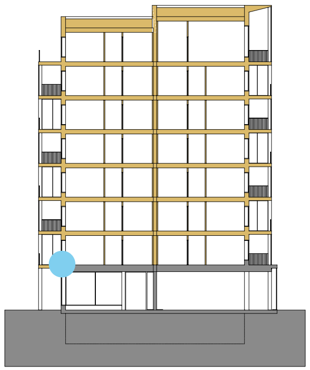


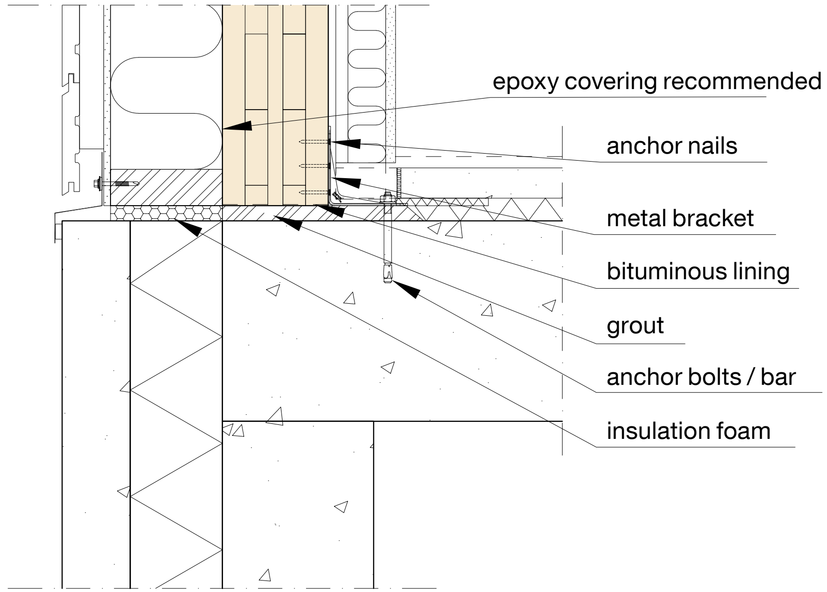




Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# FD 1 A

External wall base detail, fastening






Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

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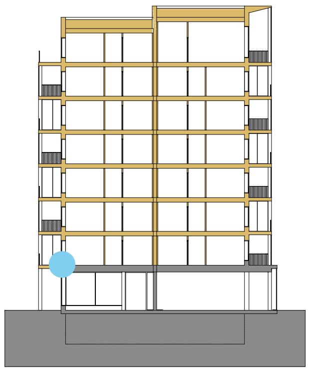
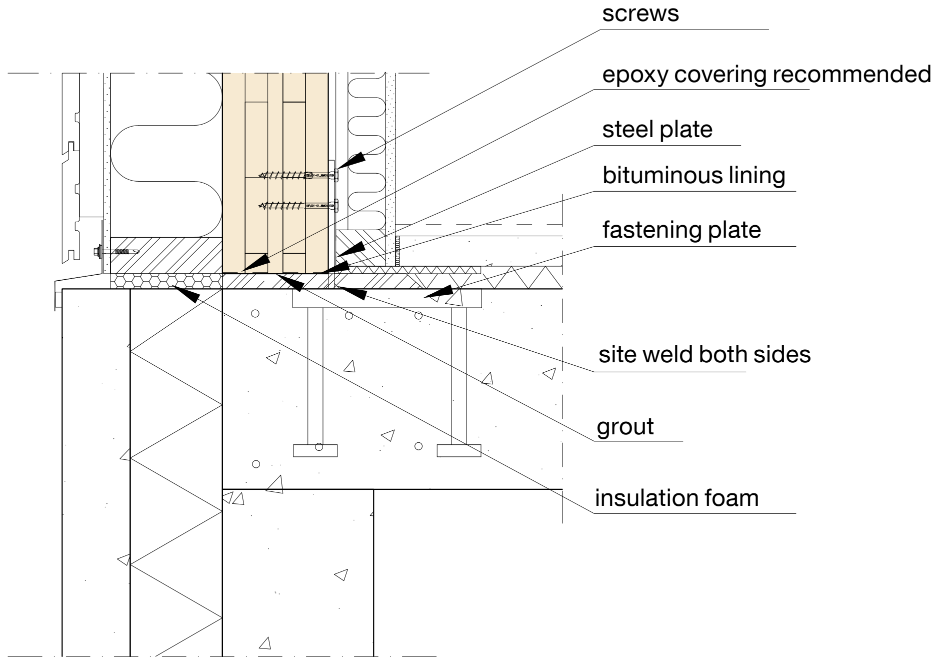
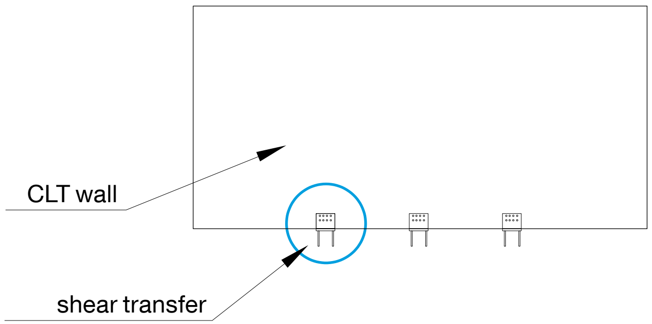
# FD 1 B

External wall base detail, shear transfer



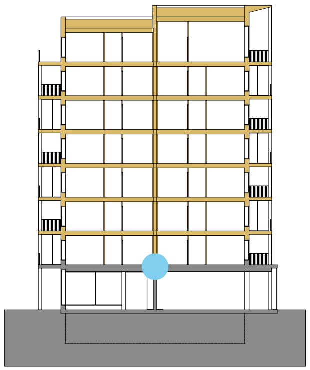


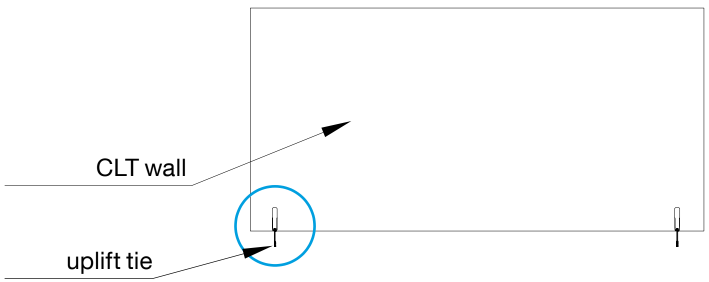



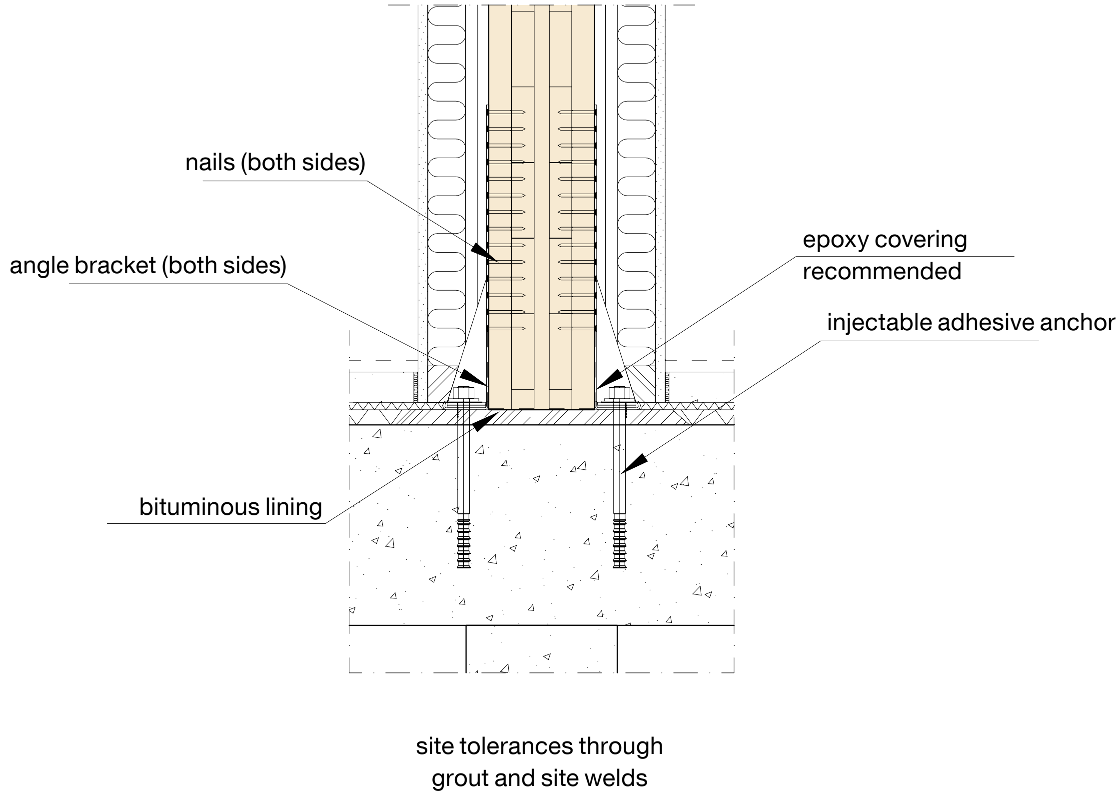

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# FD 2 A

Load-bearing partition wall, base detail, uplift tie



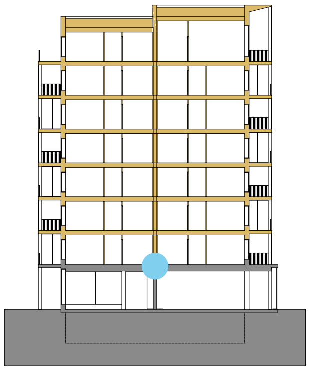


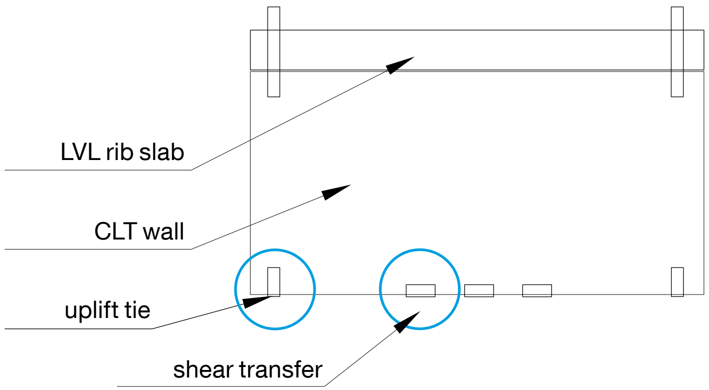



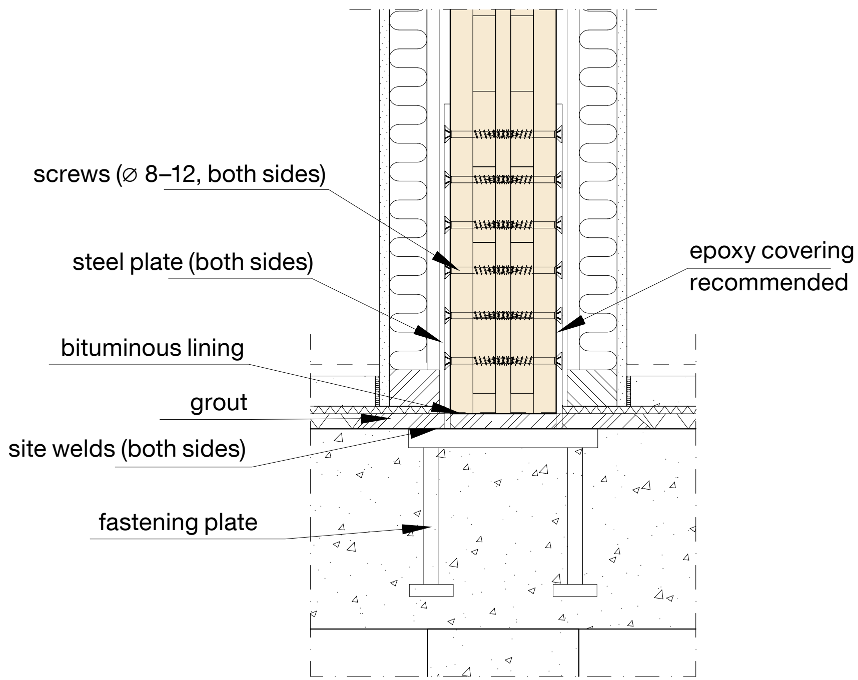

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# FD 2 B

Load-bearing partition wall, base detail, shear transfer and uplift tie





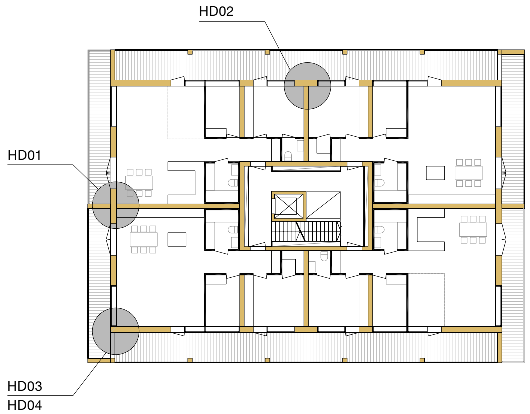




site tolerances through
grout and site welds

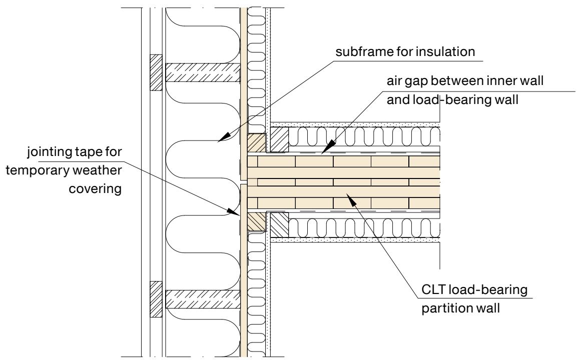
Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# HD 1-5

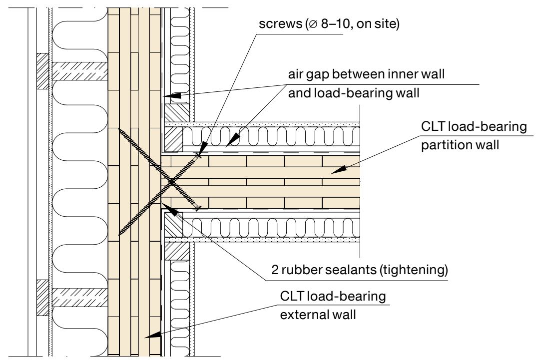
Horizontal details



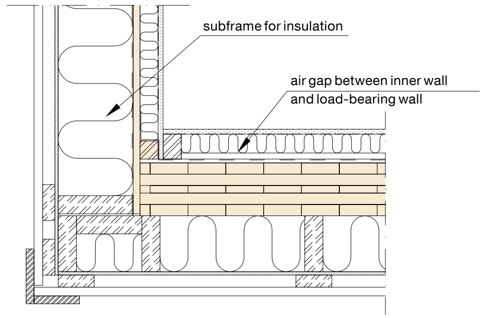

## HD01 T-connection at external wall, non-load-bearing and load-bearing walls



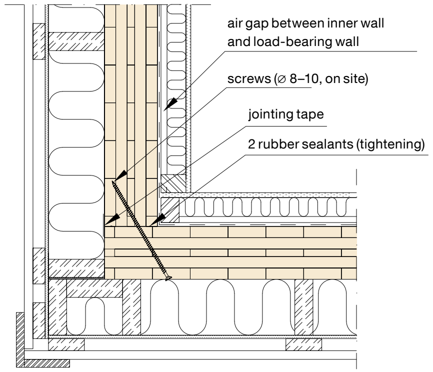

## HD02 T-connection at external wall, load-bearing walls




## HD03 Outer corner, load-bearing and non load-bearing walls

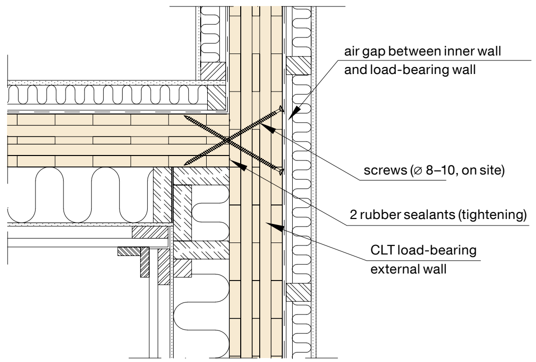



## HD04 Outer corner, load-bearing walls




## HD05 Re-entering corner

Note! Not presented in showcase.




Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

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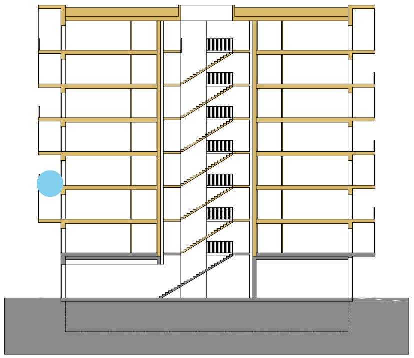
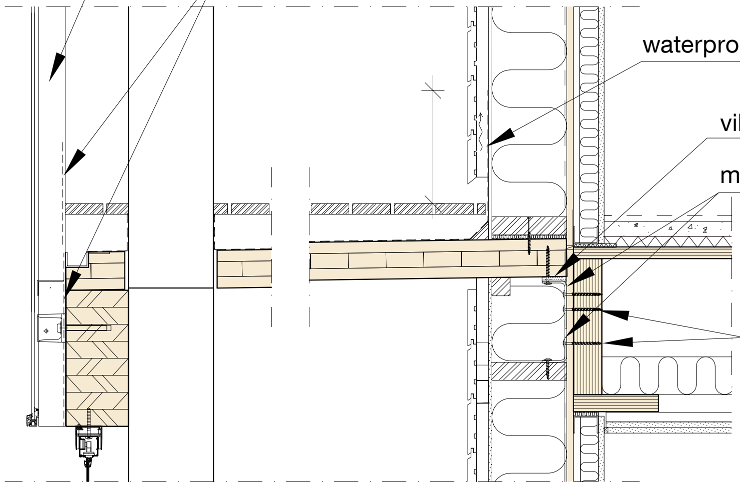
# BD 1

Balcony detail, non-load-bearing wall



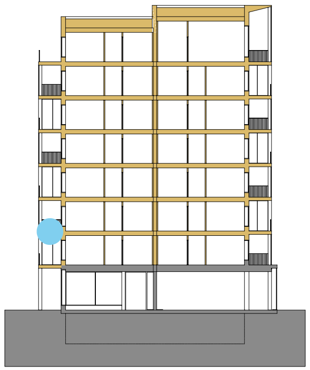


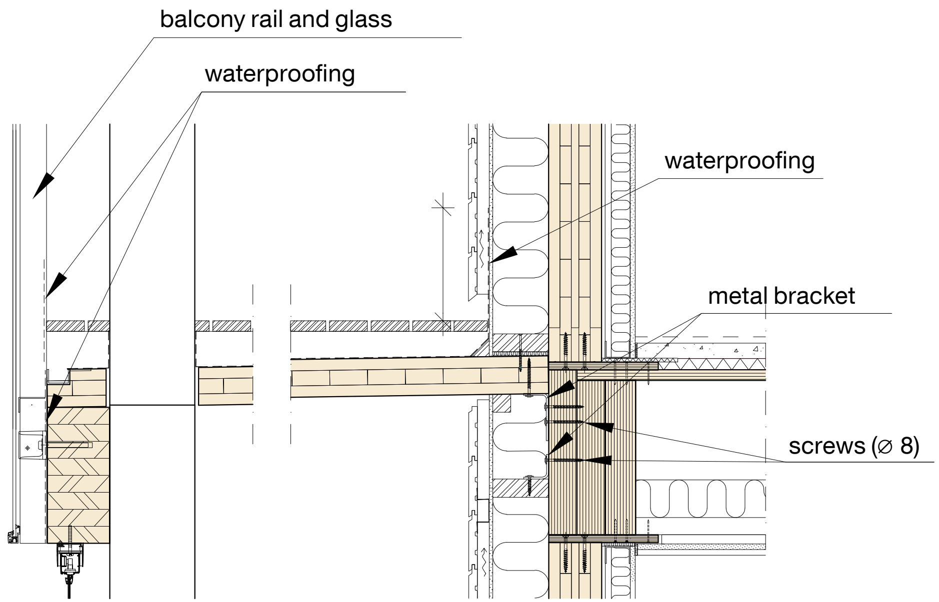

See detail VD02 for rib slab to wall fastening

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# BD 2

Balcony detail, load-bearing wall






See detail VD02 for rib slab to wall fastening

Exact amount, size and spacing of fastener according to structural engineer.
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

# 6 On-site assembly

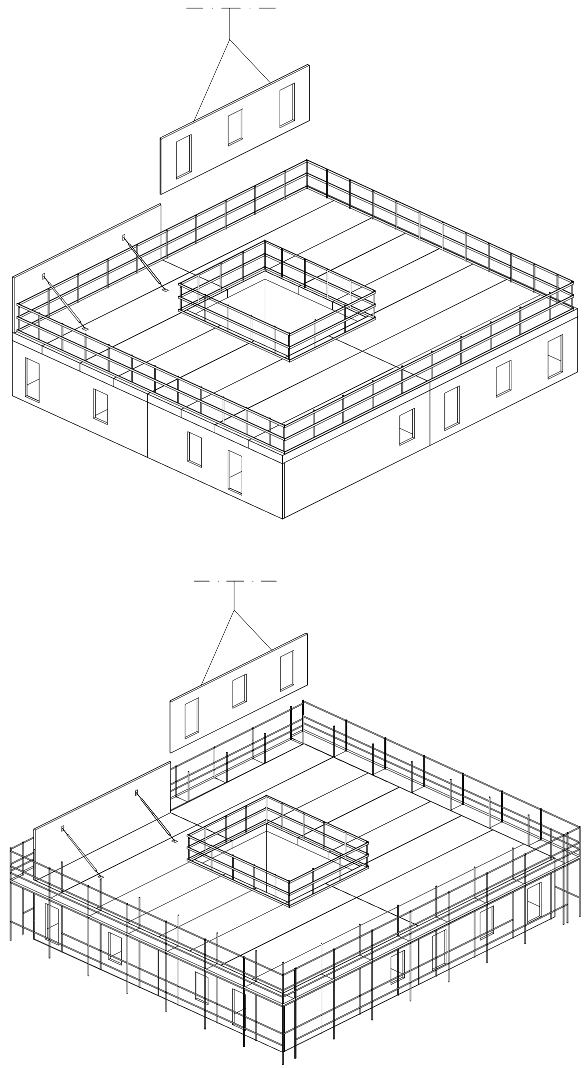
# 6.1 Principles of erection

## 6.1.1 General

- An erection scheme must be made and approved before work begins on site.
- Before beginning, insure that lifting equipment, space and weather conditions on site are sufficient for the erection period.
- The erection scheme should specify which lifting equipment is needed on site. Depending on the project this will include for instance a mobile crane or tower crane, lifting slings or chains, eyebolts, etc.
- Panels may be lifted from 2 or 4 lifting points depending on the panel.
- Lifting bolts must be planned so that they can carry the weight of the panels.
- Lifting points must be planned to keep the panel balanced while it is lifted.
- Panels with large openings must be reinforced before lifting to prevent deformation.
- Safety precautions must be considered for lifting and working at height.
- During construction the platform must not be overloaded with construction materials beyond its live load capacity.

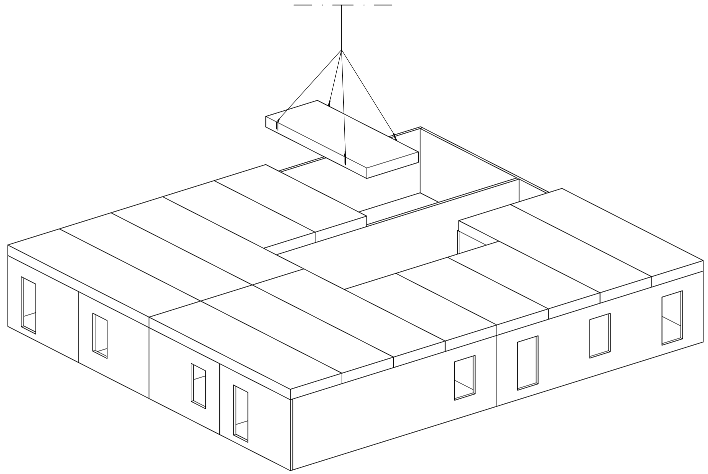
## 6.1.2 Erection of vertical walls

- Before installation visual checks should be performed to verify quality of the panels.
- The erection surface must be checked before starting erection.
- Load-bearing CLT panels and non-load-bearing wall panels should be unloaded in order of assembly or installed directly from the truck.
- As panels are prepared for lifting add-ons such as rubber sealants and plywood boards may be installed to panels.
- Panels are lifted into position and then fastened with at least two installation supports. Only after the panel is stabilized can it be detached from the crane.
- Before or after the installation of adjacent wall panels, sealants must be installed (depending on the type of the sealant).
- Once the wall panels are placed in position, they must be checked for tolerance before being permanently fastened.
- Once the entire floor is erected, additional structural elements such as beams and posts can be installed.
- A visual check of the whole floor should be carried out before moving on with the installation.
- The structure must be stabilized before installation.



### 6.1.3 Erection of horizontal CLT / rib slab

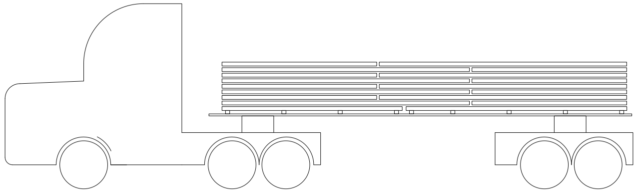
- Before installation visual checks should be performed to verify quality of the panels.
- The erection surface must be checked before starting erection.
- Panels should be unloaded in order of assembly or installed directly from the truck.
- Once a panel is lifted onto the load-bearing walls, it must be temporarily fastened to vertical walls before it can be detached from the crane.
- Rib slabs are temporarily fastened to other horizontal panels that are already in place.
- Once all slabs are in position, they should be checked for tolerance and permanently fastened.

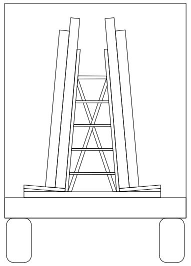


## 6.2 Transportation

### 6.2.1 Transportation of CLT panels

- Standard sized trailers can carry maximum of 25 tons of CLT panels in the horizontal position. The maximum dimensions for cargo are 13,60 m in length and 2,95 m in width. If the CLT panel is thick enough, even 16 m panels can be transported in the horizontal position with standard trailer.
- CLT panels, can also be transported in the vertical position using A-racks.
- Elements should be loaded on the truck in order of their lifting on site.
- CLT panels must be fastened to the trailer to prevent movement during transportation and edges of the panels should be protected with card-board or other layers to prevent damage from fastening straps.
- All cargo should be protected from weather with tarpaulins or alternative covering materials during transport.
- When transporting CLT with visible surfaces, bubble wrap can be used between the panels if requested. In addition, CLT panels can be packed in UV-resistant coating to ensure that the quality of the panels is preserved.





# 6.3 Protection on-site

## 6.3.1 Moisture control

- Moisture control takes part in every phase of the project from beginning to end in order to produce a healthy and safe building.

## 6.3.2 Persons in charge of the moisture control

- An expert and other persons in charge of the moisture control will be assigned to the project. Their task is to monitor and control moisture through every phase of the project.

## 6.3.3 Moisture control plan and employee engagement

- A moisture control plan should include an estimation of possible risks caused by moisture, plans for measuring and monitoring moisture levels and a scheme for controlling moisture on-site as needed.
- The whole staff on-site should be trained to take into account the basic demands of the moisture control in their work and commit to following the requirements for moisture control from beginning to end of the project.
- The demands of the moisture control plan will be taken into account in requests for estimates, quotes, contracts and site meetings if required.

## 6.3.4 Assurance of technical quality in case of moisture damage

- All moisture damage will be documented and the necessary actions required to dry out any moistened structures will be defined.
- Drying out any moistened structures must be monitored with moisture measurements and results documented.

# 6.4 Protection of structures and materials on-site

- All elements should be entirely protected during the transportation and stored without direct contact to ground (Figure 1).
- All elements should be protected against the sun during storage in order to limit deformation or colour damage to surfaces.
- All elements will be inspected before erection. Any damage occurring from transportation or storage will be documented and repaired without delay.

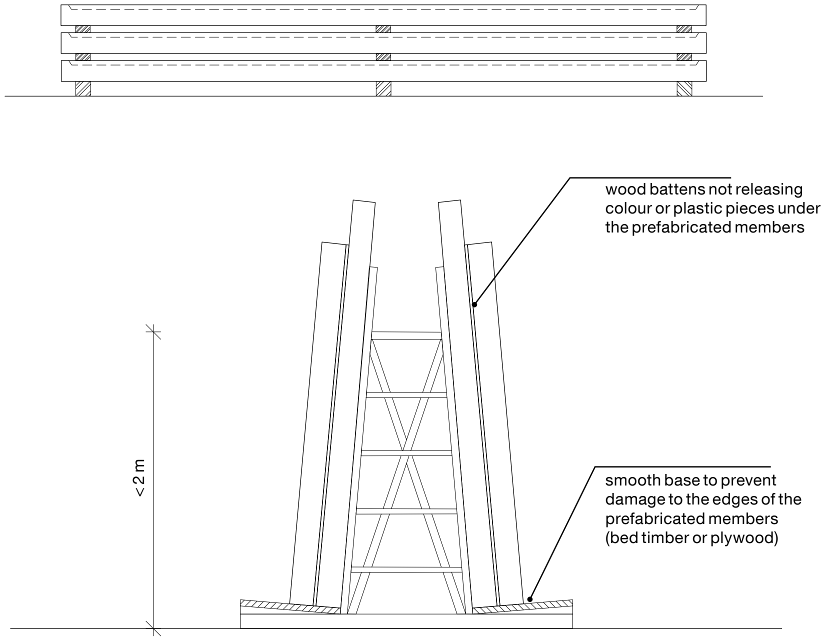



Figure 1:
Protection of wood elements on-site

## 6.4.1 Protection of load-bearing wooden wall panels

- A tent is not needed during the erection of the building structure, but the assembly of the frame structures should be planned so that structures will be open to the elements for as short a time as possible.
- In the factory, load-bearing wood elements will be treated with a hydrophobic coating in order to inhibit water infiltration.
- Connections between elements should be protected by exterior covers.
- The window and door openings should be covered with double layer plastic covers in order to begin the management of the indoor climate.
- Materials sensitive to moisture will not be installed until the external envelope has been closed.

## 6.4.2 Protection of intermediate floor slabs

- Top surfaces, edges of horizontal structures and exterior sides of edge beams will be treated with a hydrophobic coating by manufacturer.
- Recesses for prefabricated bathrooms, stairwells and lift wells will be protected with lightweight covers on-site.
- Lightweight covers will be transferred to the next floor when the erection of frame structures has progressed.
- Timber planks are installed to create drainage troughs following the plan of the unit walls. These troughs are sealed to prevent water from entering the connections between structures so that all joints of the intermediate floor units are sealed.
- Each trough is connected to a drain pipe which uses gravity to remove water from horizontal surfaces to the municipal draining system.
- Connections between wall and floor elements are protected by an EPDM-rubber strip, which is installed to the bottom of the wall unit by the manufacturer. On-site EPDM-rubber strips are attached mechanically to surrounding timber planks (Figure 2).
- In the event that building materials are stored on intermediate floors, they may be raised on timber bed in order to insure that no water is collected beneath stored materials.

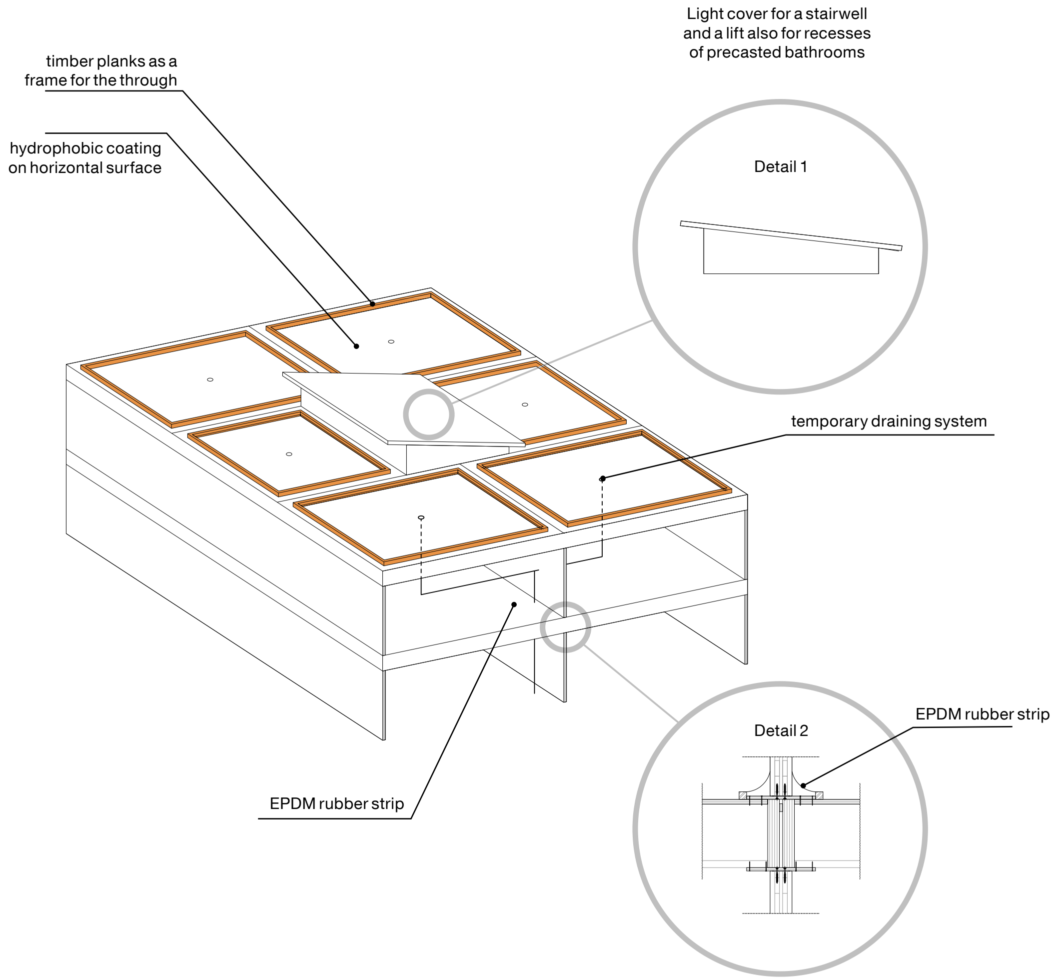



Figure 2:
Protection of intermediate floor units

### 6.4.3 Protection of non-load-bearing external wall panels

- Openings in external walls should be protected by plywood sheets or a double layer of plastic, which should be hung between the floor and the upper rib slab.
- Alternatively, non-load-bearing walls that are not insulated may be covered by a weather shield on the top part of the wall. This shield should protect the wall panel from leaking water. Window and door openings must be covered with double layer of plastic in order to begin the management of the indoor climate.
- Weatherproof materials on outer surfaces of external walls can be used as a weather shield.

### 6.4.4 Protection of the roof

- After erecting the frame structure, the roof, eaves, covering and temporary draining system will be assembled.

### 6.4.5 Management of indoor conditions

- The management of indoor conditions will begin when all load-bearing walls and intermediate floors have been erected and openings in the external envelope have been sealed.
- A heating system is set to every space enclosed by load-bearing walls in order to dry the structures.
- During construction, the relative humidity of the indoor air is to be kept under 75%. After the installation of thermal insulation, the relative humidity of the indoor air must be between 45% and 55% with the temperature above +10 °C in order to effectively dry all structures.
- In order to ensure drying of the structures in all spaces, two monitoring stations will be set up to record interior conditions (measuring relative humidity and air temperature). Data collected from these monitoring stations will be analysed weekly and management of indoor air conditions will be adjusted in accordance with the collected data.

### 6.4.6 Inspections to be conducted prior to the installation of coating materials

- The moisture technical functionality of all internal and external structures are inspected before starting to install internal coatings.
- The condition of external and internal wood surfaces will be checked by sensors.
- Moisture content of all external and internal wood surfaces should be measured and charted.
- Using data from these moisture measurements, estimates for coating can take into account the quality required for the specific conditions.
- Criteria for the coating will be determined by the types of structures and the moisture control plan.
- Damaged materials must be replaced before installation of internal materials can begin.
- Confirmation of moisture measurements, if necessary, can be made by drying / weighing measurements and measurements of the relative humidity of the pore air.

# 7 Sustainability

# 7.1 Stora Enso building solutions for sustainable homes

Sustainable homes aim at balancing the needs of today and those of future generations; they are built without depleting natural resources and without other harmful environmental and social impacts. Today, sustainable homes mostly aim at reducing carbon emissions, and at providing healthy and comfortable living conditions for occupants, considering the whole building life cycle including the production of construction materials. These aspects of sustainability are increasingly subject to tightening legislative requirements and voluntary third-party verification. In relation to the latter, many building rating systems exist and provide viable tools for the communication of a building's sustainability credentials.

Stora Enso building solutions help designers, contractors, owners and tenants achieve compliance and address their sustainability ambitions.

## 7.1.1 Responsibly sourced renewable wood for low carbon building solutions

Stora Enso's construction materials and building solutions are based on low environmental impact, renewable wood from sustainably managed forests. Wood for Stora Enso's wood products and building solutions originates from semi-natural, sustainably managed European forests, which grow by area and by volume. The European forests contribute to the social welfare and livelihood of local communities and regions with 16 million forest owners. Parallel multiple uses of these forests for recreation and nature conservation are integral parts of sustainable forestry practices.

Stora Enso promotes third-party certification of forest management, with demands that go beyond legal requirements. In 2015, already 80% of all wood that was used by Stora Enso's mills originated from PEFC™ or FSC® (C125195) certified forests. For verification of the responsible and legal wood origin, Stora Enso applies PEFC and FSC Chain of Custody certified wood traceability systems.

In the production of wood based building solutions, Stora Enso's mills apply ISO and OHSAS based management systems to ensure responsible, efficient, clean, and safe working environments. Energy is mostly produced using biomass generated from sawmill residues, avoiding fossil carbon emissions. High yields and efficiencies in the use of wood ensure that no wood goes wasted.

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Wood construction plays an increasing role in global warming mitigation and adaptation strategies as it helps to reduce the fossil carbon emissions. Sustainable, growing forests store carbon dioxide from the atmosphere. Wood construction materials store an amount of carbon equal to approximately half of their dry weight and wooden buildings are carbon storages during their lifetime. At end of their useful life, wood products can be re-used, recycled or used as none fossil fuels for energy production.

### 7.1.2 Energy efficient and low carbon homes

Buildings use approximately 40% of total EU energy consumption [1]. Reduction of energy use in buildings is one of the most economical ways to mitigate carbon emissions. The Energy Performance of the Buildings Directive (EPBD) [2] is the main policy tool by the European Union to reduce energy use in buildings within the EU member states.
Furthermore, the Renewable Energy Directive (RED) [3] aims at increasing the share of renewable energy in supply to buildings, herewith further driving down carbon emission from the use of buildings.

The EPBD is driving the constant improvement of energy performance of buildings, building elements and technical systems. The performance is defined and updated in national building regulations. According to the EPBD, as of the beginning of 2021 all new buildings will need to be nearly zero energy buildings (nZEB) in the EU member states. nZEBs are buildings with very high energy performance and their energy requirements are covered by renewable energy sources to a significant extent. In each EU member state energy performance levels and nZEB are defined differently using a methodology considering associated life cycle costs. Stora Enso wood based building solutions offer a wide range of properties that fit the nZEB definition well in the Central and Northern European countries. CLT structures for use in the Nordic climates have been analysed for their building physical and energy performance. Insulated CLT and other wooden structures can have U-values down to 0.1 $W/m^2K$ and even below without any moisture risks and associated risks to the indoor climate.

With energy use in buildings heavily regulated and quickly approaching nZEB, efforts to lower the environmental impact of buildings are now focusing more and more on lowering energy consumption and carbon emissions associated with the production of building materials and the construction of buildings. The use of Stora Enso low carbon building solutions help lower environmental impacts relative to existing homes and construction practices [4, 5].

1 http://ec.europa.eu/research/press/2013/pdf/ppp/eeb_factsheet.pdf
2 Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings.
3 Directive 2009/28/EC on the promotion of the use of energy from renewable sources.
4 Environmental Improvement Potentials of Residential Buildings (IMPRO-Building) 2008
5 Wood in Carbon Efficient Construction — ECO2. http://www.eco2wood.com/

## 7.2 Occupant health and wellbeing — Indoor climate and thermal comfort

Thermal 'sensation' is a parameter that reflects the thermal comfort in a building. Cold surfaces can cause the feeling of draught even though the building envelope is airtight, as the human body radiates heat towards colder surfaces of a room. Optimised thermal insulation guarantees suitable surface temperatures of walls and the roof of a building to mitigate uncomforting indoor conditions.

Moisture damages in building structures are one of the critical causes of poor quality of indoor air and associated health problems such as asthma and respiratory disorder [6].

There are several classifications that help define good indoor air quality, e.g. the Finnish Classification of Indoor Environment 2008. It is a voluntary system for setting target values for the indoor environment in new buildings. Highly insulated CLT based structures contribute to indoor climate in varying means for example:

- good thermal insulation enables even temperatures in a room [7]
- natural wooden materials have low emissions during the use of a building
- use of wood as an interior design element can contribute to pleasant living and working environment [8]

Comfort and indoor air quality are becoming increasingly important criteria to customers when renting or buying their home. Stora Enso building solutions promote good and healthy indoor climate.

6 European Respiratory Journal. 2007 March, 29(3):509-15
7 Holopainen, R. A human thermal model for improved thermal comfort. Dissertation. Espoo 2012. VTT Science 23. 141 p.
8 Nyrud A, Bringslimark T, Bysheim K, Health benefits from wood interiors in Hospitals. Norwegian Institute of Wood Technology.

# 7.3 Elements of life cycle design in CLT and LVL[1] based buildings

Life cycle design refers to a structured co-operation between designers, contractors, material suppliers, and possibly other project stakeholders. Life cycle design aims to achieve building solutions that consider life cycle costs and contribute to higher construction quality, longer service times, good indoor environment, low energy demand as well as carbon emissions and hence life cycle design helps the delivery of sustainable homes.

New buildings are typically designed for a service life of 50–100 years. Longer service life using wood construction has been proven throughout history. Components such as fans, pumps, piping, surface coatings, waterproofing, façades, window frames, however, have a typical service life of 25–50 years. Therefore, a long service life requires a life cycle approach that addresses:

- shorter life time components are designed for replacement
- long-term maintenance
- maintenance, periodic condition surveys and timely repairs
- load-bearing CLT structures located on the inside of the thermal insulation layers and thus protected from outdoor climate impacts
- high quality construction of the building, building elements and components

Stora Enso building solutions are prefabricated building elements produced in tightly controlled factory conditions that improve the quality and ease of construction.

High quality construction and a long service life of a building, drives a reduced demand for renovation and refurbishment, and herewith reduces material use, waste generation, and energy use in the production of materials, transport and construction, further enhancing a building's sustainability performance.

# 7.4 Certification of sustainable and low carbon homes

Dependent on the market conditions and customer awareness, the use of certification systems may provide good marketing and communication tools towards customers, authorities and/or investors and may in some markets help increase market value. There are a number of different certification systems that provide third-party validation of building performance for sustainable homes, such as (but not limited to) BREEAM, LEED, DGNB, HQE, Miljöbyggnad, and Minergie. These systems typically stress the energy efficiency and low carbon emissions, indoor climate and thermal comfort, low material emissions, life cycle design and assessment, and construction process procedures, etc. in grading for certification.

1 Commercial production of LVL will start end of quarter 2, 2016.

## Sustainability information on verification and certification:

- Chain of Custody certificates (PEFC™ and FSC®) for responsibly sourced wood from sustainable and legal sources available at *http://www.storaenso.com* > *Sustainability* > *Certificates*
- Wood from sustainably managed certified forests
- Ask for our PEFC™ or FSC® (C125195) certified products
- Certificates for responsible, efficient and safe manufacturing processes available at *http://www.storaenso.com* > *Sustainability* > *Certificates*
  - ISO 9001 quality certificate
  - ISO 14001 environmental certificate
  - ISO 50001 energy efficiency certificate
  - OSHAS safety certificate
- Carbon footprint and Life Cycle Assessment
  - case specific carbon footprint calculations available upon request
- Product environmental information and Life Cycle Assessment
  - product specific Environmental Product Declarations (EPD) soon available at *http://buildingandliving.storaenso.com* > *Sustainability*
  - product specific indoor air emission declarations available upon request
  - product specific chemicals declarations, etc. available upon request

# 8 Stora Enso

# 8.1 Stora Enso

Stora Enso is a leading provider of renewable solutions in paper, packaging, biomaterials, wood products and wood constructions on global markets. Our customers include publishers, retailers, brand owners, print and board producers, printing houses, merchants, converters and joineries and construction companies.

Our aim is to replace fossil based materials by innovating and developing new products and services based on wood and other renewable materials. We believe that everything that is made with fossil fuels today can be made from a tree tomorrow. Our focus is on fibre-based packaging, plantation-based pulp, innovation in biomaterials, and sustainable building solutions.

Stora Enso recorded sales of €10 billion in 2015 (with an operational EBIT of €915 million) and it employs some 26,000 people in more than 35 countries around the world. Stora Enso shares are listed on the Helsinki and Stockholm stock exchanges.

We use and develop our expertise in renewable materials to meet the needs of our customers and many of today's global raw material challenges. Our products provide a climate-friendly alternative to many products made from non-renewable materials, and have a smaller carbon footprint.

Being responsible — doing good for the people and the planet — underpins our thinking and our approach in every aspect of business.

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