Building Systems by Stora Enso

3–8 Storey Modular Element Buildings

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1 Introduction and disclaimer

1.1 Introduction

This manual describes the Stora Enso modular element system for wooden multi-storey residential buildings. It is intended for designers, contractors, building owners and developers.

The core of the system are Stora Enso's structural wall panels and floor slabs, which form the strong and stable load-bearing structure of each modular element. The elements are built in controlled factory conditions and delivered to the site with all finishing materials and components installed. The technology provides high technical performance and outstanding quality. These elements enable an industrial method of construction that reduces assembly time on site and minimizes the need for finishing work on site.

The building system is flexible and can be adjusted to various market and customer requirements depending on local needs. 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)
- level of prefabrication (interiors and façades)

The manual offers a good overview of common European structures and building types, but should also give 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 involved in the 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

For contractors and carpenters, it provides:

- safe solutions — tested and proven instructions for the whole building process
- fast assembly times
- a proven structural system
- ready-made solutions – easy cost and design management
- industrial components with factory precision — less finishing work on site
- 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 (in accordance with local fire requirements)
- 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
- technically safe and durable solutions

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 customized for varying appearances, building types and sizes
- an industrial quality — all critical phases have been built in controlled circumstances
- an attractive object of investment for environmentally conscious persons

1.3 Disclaimer

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

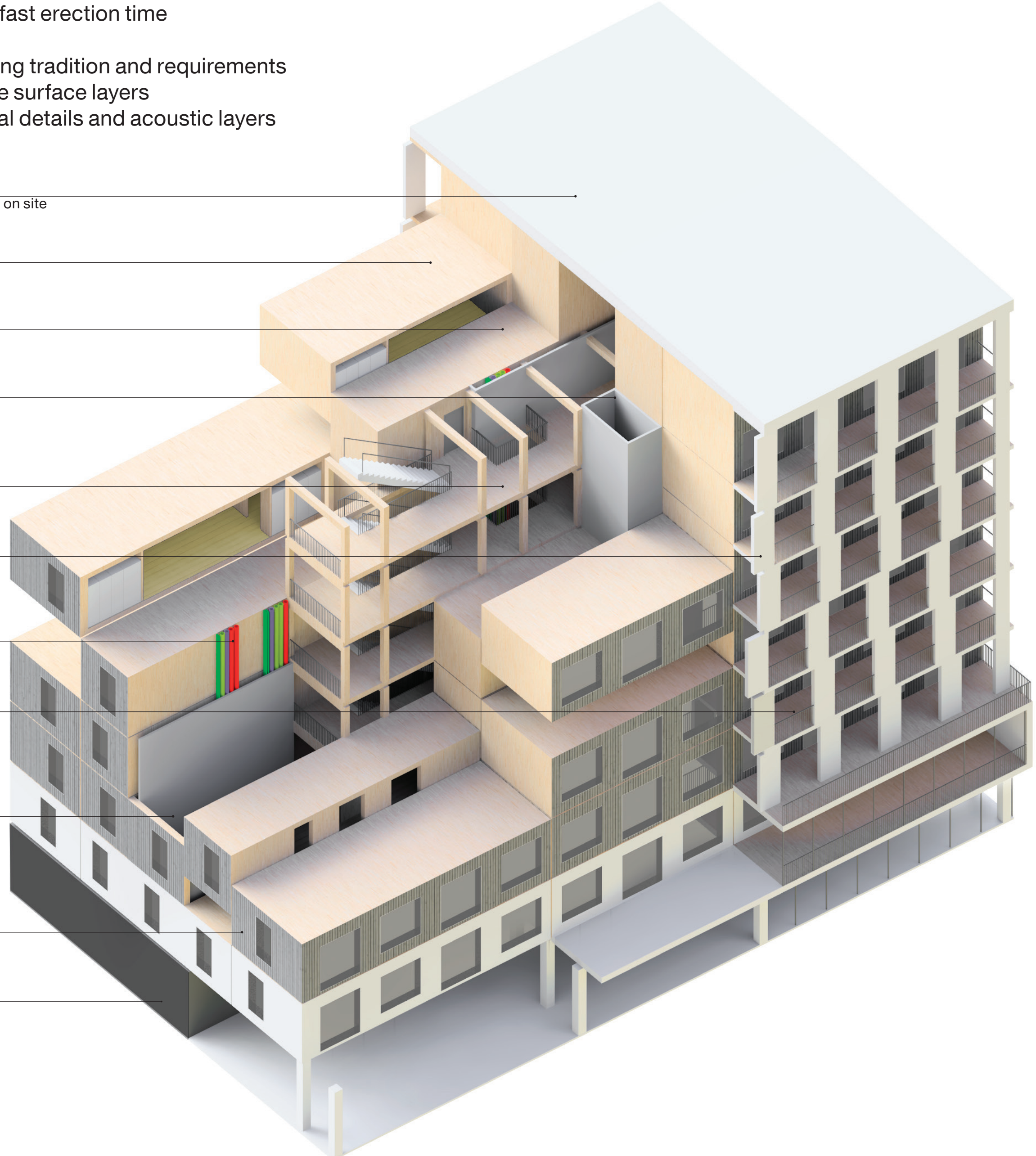
The use of the structural solutions (and reference values) shown here does not replace the need for final design and calculations by responsible designers (including but not limited to structural, acoustic, fire or building physics experts). All solutions and details used in construction should be reviewed, 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 merchantability 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 modular building system

2.1 Anatomy of a modular building

- Ready-made modules and optimised details — fast erection time
- Stiff and rigid central core
- The system can be localised to meet local building tradition and requirements
- Fire safety with massive wood and fire protective surface layers
- Acoustic performance with engineered structural details and acoustic layers



roof
- made with prefabricated elements and/or constructed on site

room modules
- prefabricated

technical modules
- prefabricated

elevator shaft
- massive wood
- note local fire regulations

central corridor (assembled on site)
- massive wood slabs, beams and stairways

façade
- assembled in factory or on site
- different façade materials are possible

HVAC installations / vertical shafts
- assembled on site

additional elements (balcony zone)
- prefabricated elements
- technically possible to use different balcony types
- railings / glazing

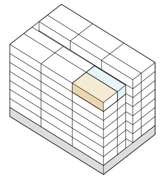
surface structures
- finished on site after technical installations

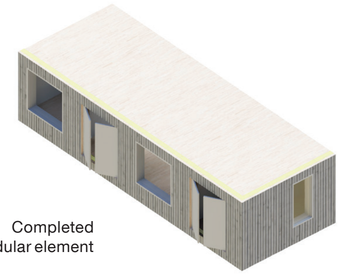
additional elements
- façade panels

concrete ground floor / basement / foundation
- commercial spaces / multipurpose spaces
- storage rooms / technical rooms
- constructed on site

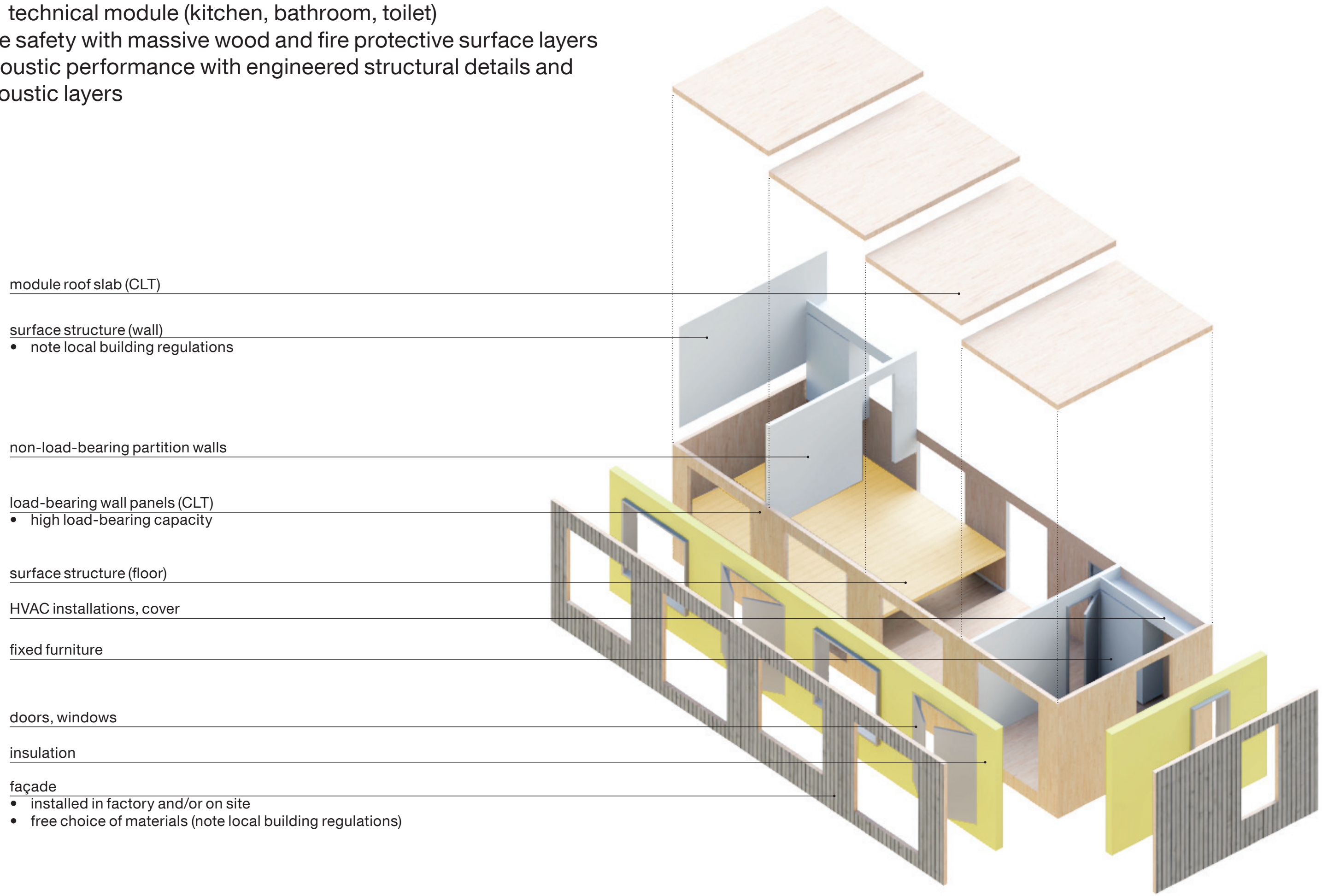
2.2 Anatomy of a modular element

- Prefabricated in factory conditions
- Finished surfaces, pre-fitted technical installations and pre-installed fixtures and fittings
- Basic modules:
  - room module (living room, bedroom, dining room, workspace)
  - technical module (kitchen, bathroom, toilet)
- Fire safety with massive wood and fire protective surface layers
- Acoustic performance with engineered structural details and acoustic layers

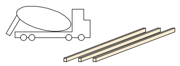
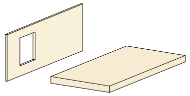
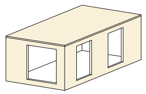


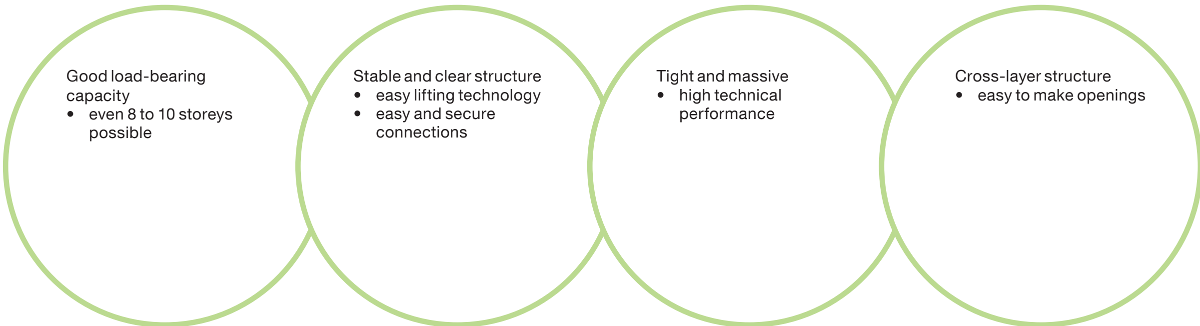


Completed modular element



2.3 Element systems in the field of construction technologies

	Building components	Prefabrication	Dimensions	Complexity	Construction
BUILDING ON SITE	building products 	low grade of prefabrication	no limitations in size	demanding and unique shapes	long construction phase
ELEMENT	factory finished two dimensional surfaces 	high grade of prefabrication	wide range of possible dimensions	repetition of panels and slabs	shorter construction phase
MODULAR ELEMENT	factory finished three dimensional elements 	extremely high grade of prefabrication	limited dimensions	repetition of modular units	shortest construction phase

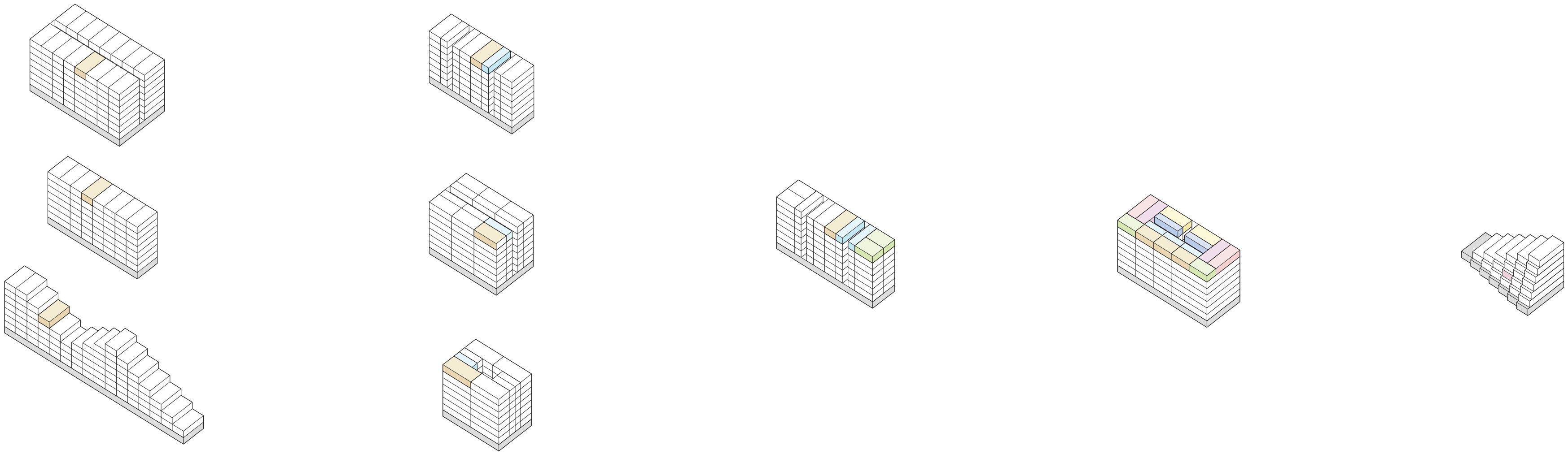


Benefits of massive wood structure

3 Architectural design guidelines

Modular system

Possibilities and benefits of the system related to repetition and variation



A | A + B | A + B + C | A + B + C + D + E + F + G | ABCDEFGHIJKLMNOP...

Module variation: A
Repetition: 1 × A... n × A

Module variation:
A–B–C–D–E–F–G...
Repetition: —

Maximum repetition with minimum variation of modular elements

Typical examples:

- hotels
- small apartment housing
- student housing
- elderly homes

Optimal variation and repetition of modular elements defined by project design

Benefits in project economics and architectural quality

Typical examples:

- normal multi-storey housing

Unlimited variation of modular elements with minimum repetition

Typical examples:

- exclusive housing
- special projects

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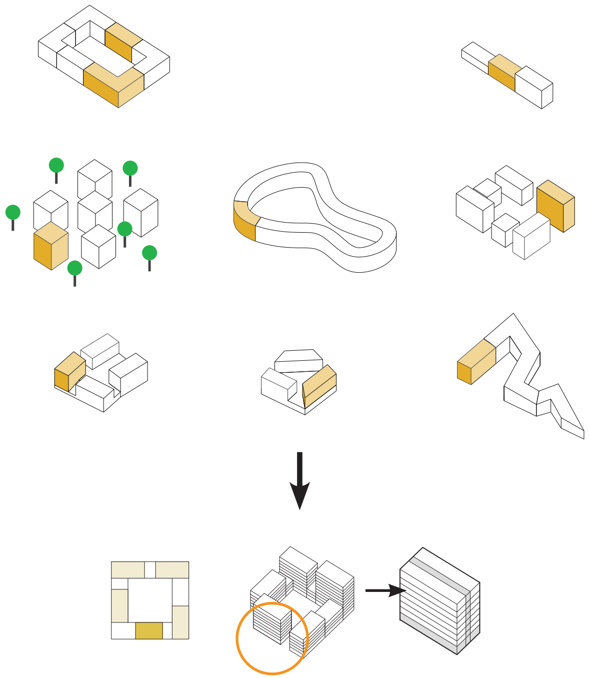
The following guidelines are meant to help architects apply the Stora Enso system to the particular needs of various types of multi-storey housing. These basic principles may be applied in any order according to the particular needs of the project. However, distribution of modular room and technical elements should be considered and applied in the early stage of design.

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.

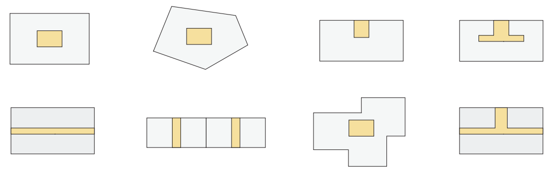


Case study example:
8-storey central corridor block

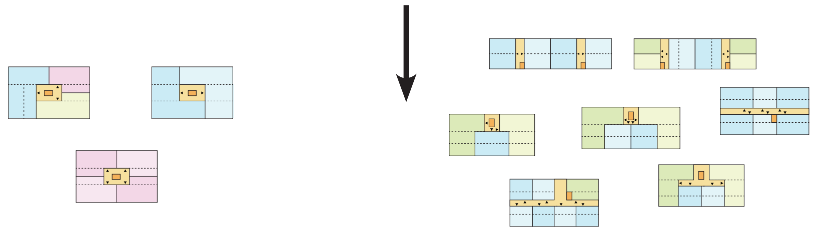
Define the building typology

Footprint, unit distribution and vertical circulation

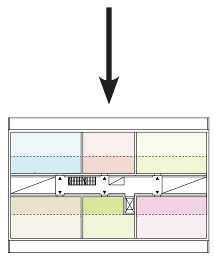
The footprint of the building as well as the distribution of living units, shape and position of the vertical access core form the basic parameters of the building structure. A symmetrical layout with a central core will optimise the load-bearing structures and shear walls, improving the economics of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



Variations in building footprint and location
of the vertical access core



Variations in unit types and distribution



Case study example:
central corridor block with six units per floor

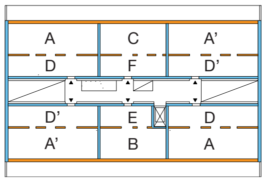
Structural principles and bearing elements

Modular elements, shear walls and load-bearing walls

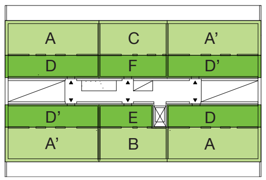
Modular elements form the base of the load-bearing and shearing structural system. Core walls and walls dividing apartments are usually the most suitable for use as shear and load-bearing structures. However, even long shear wall panels may still have openings or doors depending on detailed structural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

Load-bearing outer walls and slabs of the modules are designed to achieve optimal spans and usually eliminate the need for load-bearing elements inside the modular units. The direction of the modular elements defines which façades will have increased flexibility for larger and more frequent openings.

See chapter 4 for further information.



shear walls
load-bearing walls

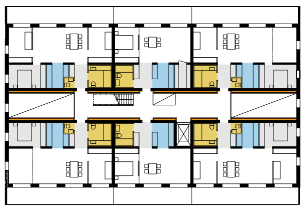


room module
technical module

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 and technical modules should also be situated next to installation shafts. Prefabricated sanitary or technical units inside modules are all possible. Specific locations for baths, toilets and kitchens may vary inside these technical modules. Long horizontal drain lines and vertical lines or shafts through elements should be avoided.



vertical shafts / installations
technical module
bathroom / toilet
kitchen

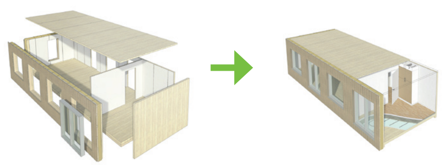
Modular elements (factory made)

Stora Enso's structural wall panels and floor slabs form the load-bearing structure of each modular element. The elements are built in controlled factory conditions and delivered to the site with all finishing materials and components installed.

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

Surfaces and finishes for interior and exterior structures of the modules can be defined individually for each project in accordance with architectural design, technical needs and local requirements.

Exact boundary rules for modular elements are not possible as rules are both factory and country specific. Element dimensions are limited by the size of the production line and transport, whereas weight is limited by the lifting capacity in the factory and on the building site.



See chapters 4 and 5 for further information.

Variable and additional elements (on site)

Corridors and stairways, elevator shafts, roofs and balconies

The building system consists of factory made modular elements and additional elements assembled on site. Prefabricated additional elements such as corridors (slabs, beams, columns, stairways) and roof are installed simultaneously with module erection phase. For example, a wide variety of balconies is possible according to the architectural needs and structural design.

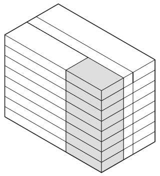
See chapter 4 and 5 for further information.

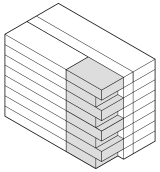
fully equipped floor plan

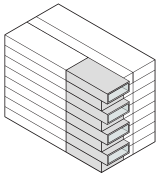
Modular system variations

Modular element variations

- Modular elements can be varied within a building
- Note that cantilevered elements may require columns, depending on the openings and the cantilever length.

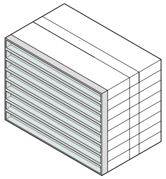

standard modules

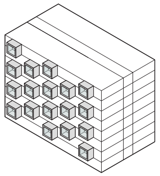

cantilevered / recessed modules

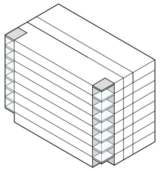

cantilevered balconies

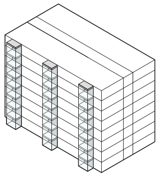
Balconies

- Different balcony types and other additional elements are possible according to the architectural design.


balcony zone

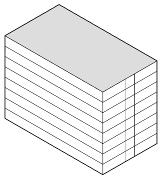

suspended balconies

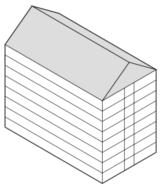

recessed balconies

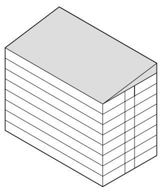

free standing balcony towers

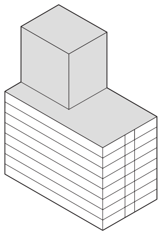
Upper floor — roof structures

- Upper floor apartments and roof structure can be varied according to the architectural design.


flat roof


pitched roof

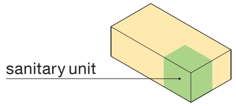

shed roof

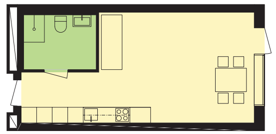

rooftop terrace

Apartment layout

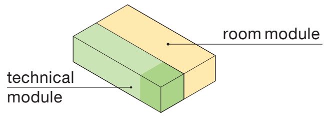
Apartments consist of one or multiple modules, depending on housing typology. In single-module apartments sanitary unit and technical systems are all in one, a so called technical or “wet” module. In double or multi-module apartments, “dry” room modules are added and connected to the technical module to achieve larger units.

Single-module apartment

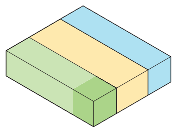




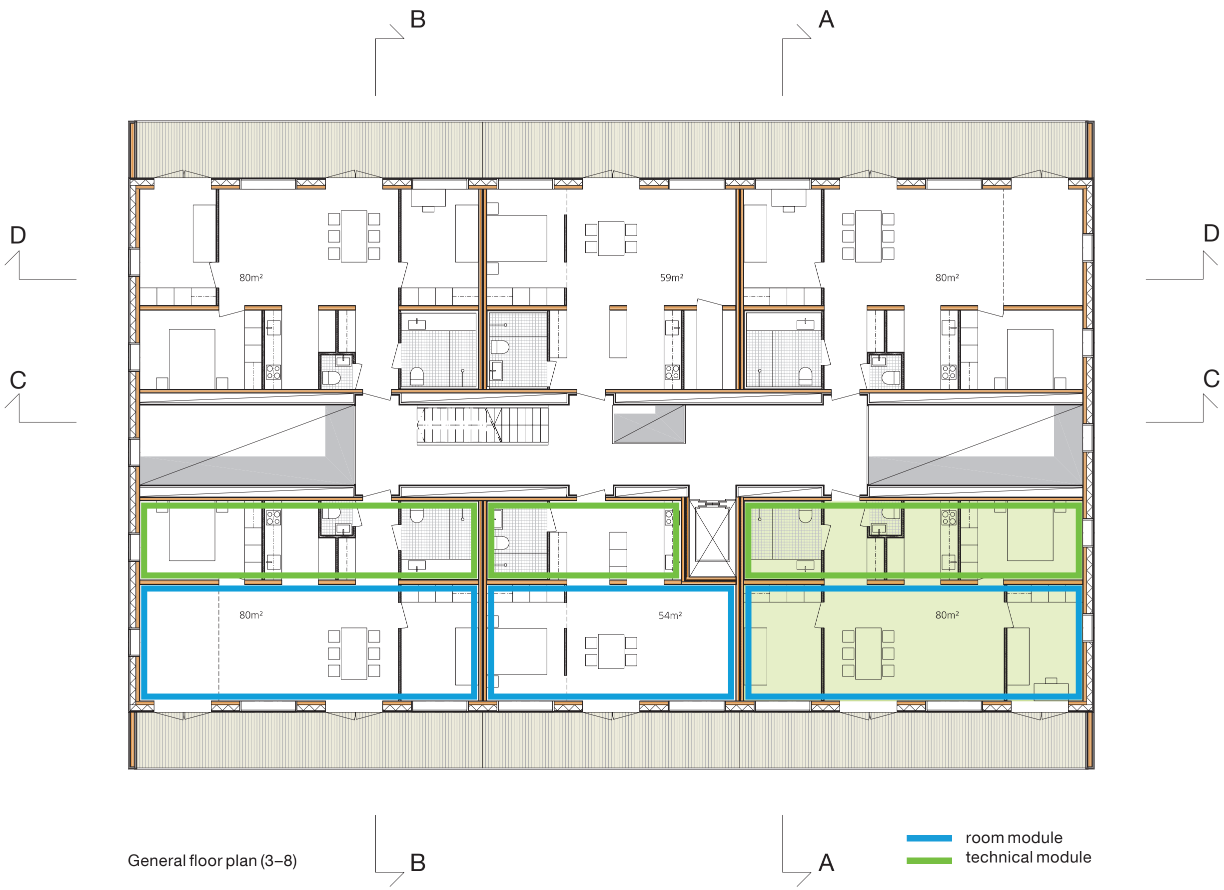
Double-module apartment



Multi-module apartment

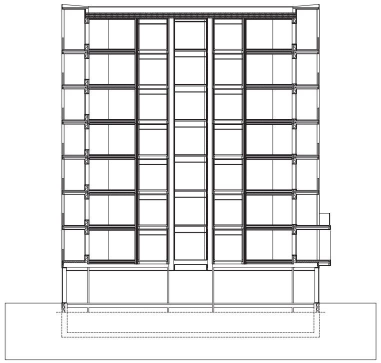


Case study example:
Central stairway with six units per floor

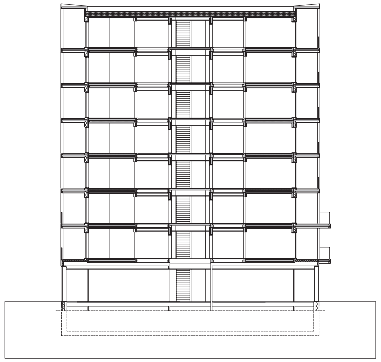


General floor plan (3–8)

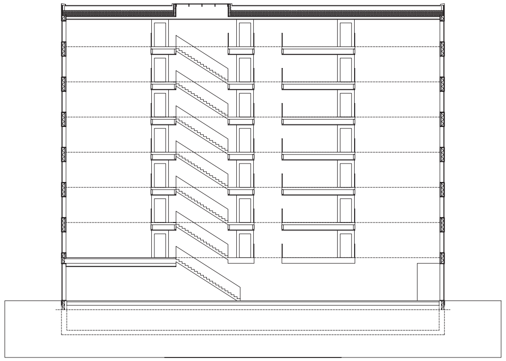
rendered elevations



cross-section a-a



cross-section b-b



cross-section c-c

cross-section d-d

4 Building System by Stora Enso

4.1 Structural components of the modular system

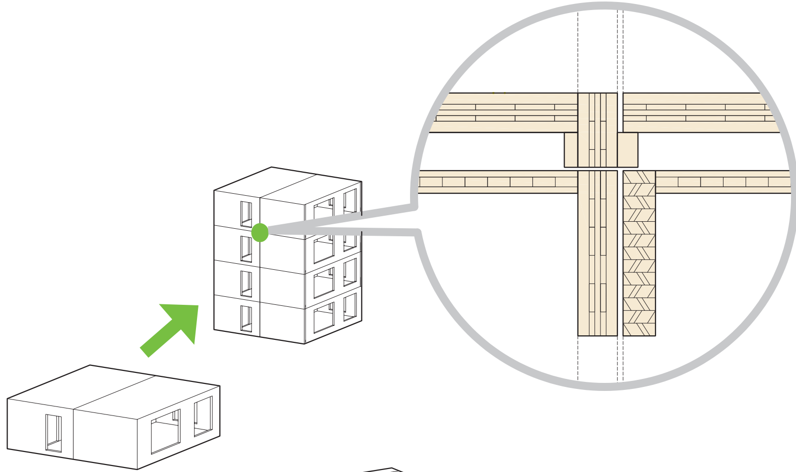
The core of the Stora Enso modular element consists of massive wood panels, which operate simultaneously as the bearing structure and the solid envelope of the apartment. In most cases it is also possible that some of the massive wood panels function as visible interior surfaces.

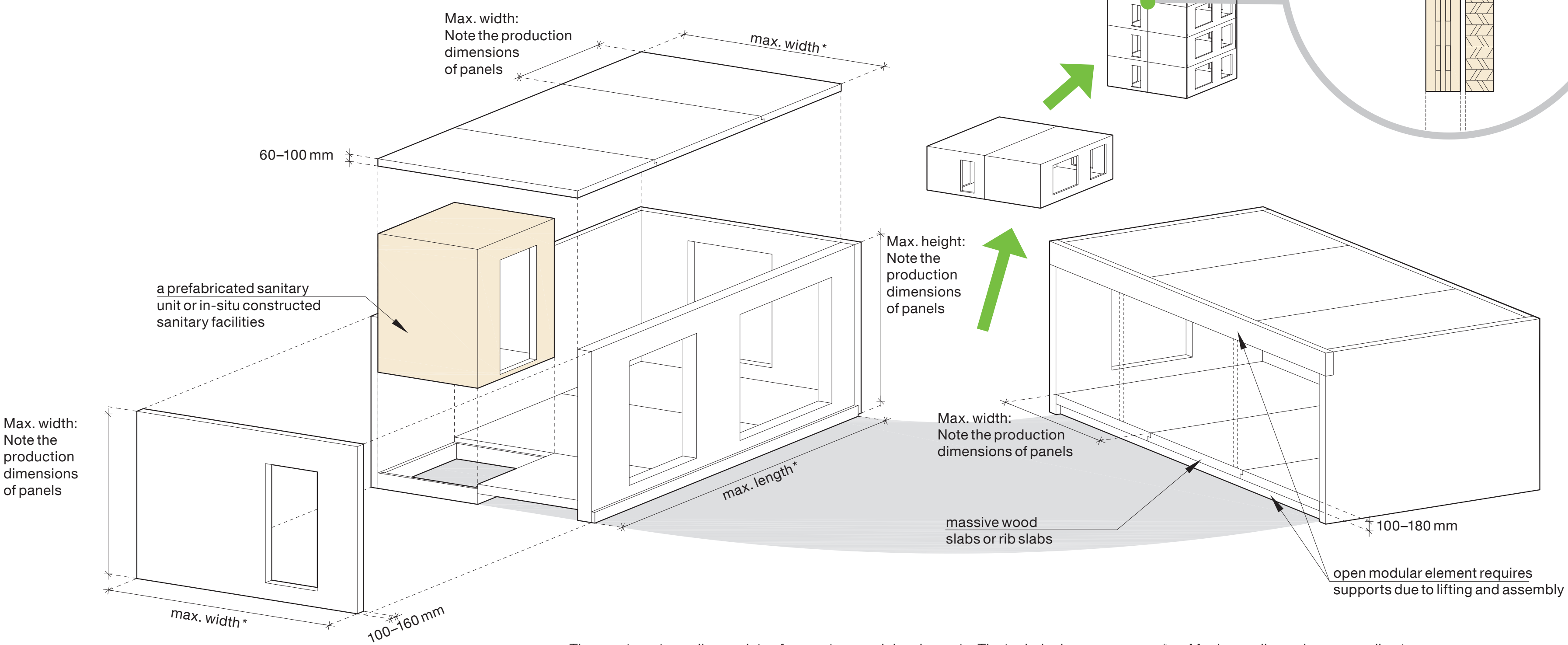
There are several factors that determine the maximum size of the modular element. The dimensions of the modular elements are limited by:

- maximum production sizes of massive wood panels
- each country's size limits for road transportation
- spatial limitations of the manufacturing environment
- maximum weight of the modular element.

The modular element must be light enough to be handled and lifted both in the factory and on the site. The maximum weight of the modular element depends on the capacity of the available lifting equipment. Notice that modular elements with sanitary facilities are heavier in relation to the volume.

Massive wood slabs





Massive wood walls

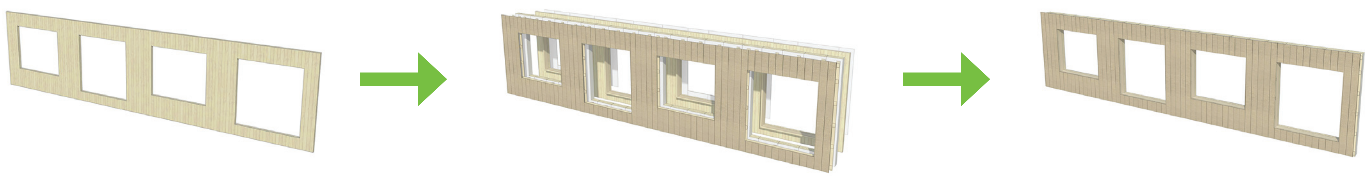
The apartment usually consists of one or two modular elements. The technical module (on the left) includes the sanitary facilities and most of the building services equipment of the apartment. To form bigger apartments with more bedrooms and living space, the apartment can be enlarged with a room module (on the right).

* Maximum dimensions according to transportation, manufacturing and lifting requirements. Also note the production dimensions of massive wood panels.

4.2 Manufacturing process of the modular elements

Slab elements

Wall elements

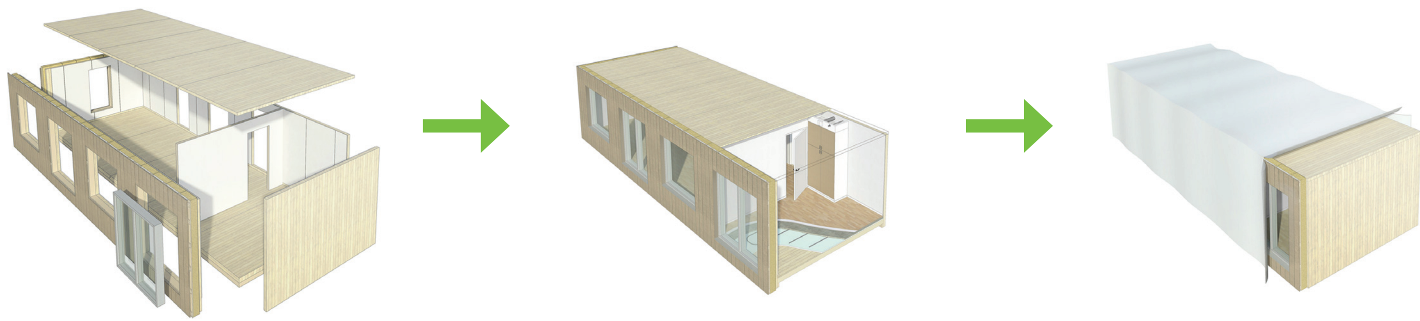


Massive wood panels are ordered with ready cut-outs and edge formings.

The panels are equipped with insulation, sheetings, frame structures, etc.

The slab and wall elements are ready to be connected to each other.

Modular elements



The wall and slab elements are connected to form a modular element.

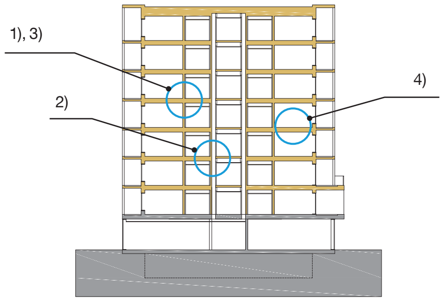
Building services equipment, interior surfaces and fixtures are installed into the module.

Once it is ready, the modular element is wrapped and transported to the site.

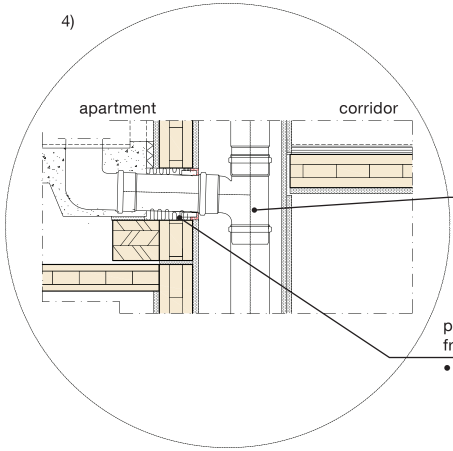
4.3 Principles of building acoustics

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 calculated on the basis of structural types and typical material values.



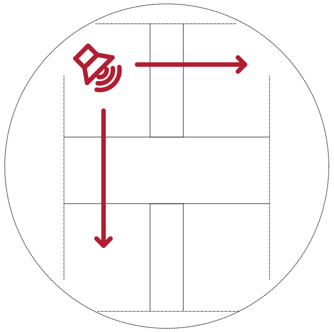
Plumbing noise



main plumbing lines at the corridor
- reduces noise to the apartment

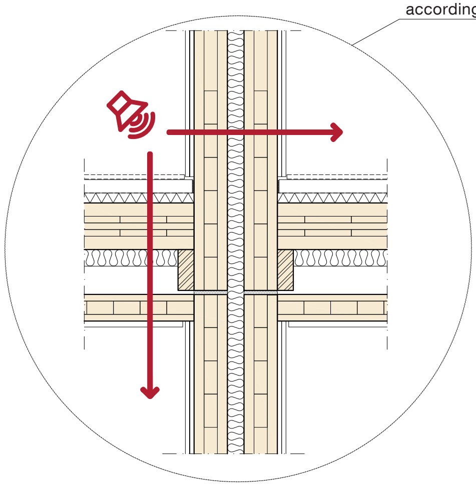
plumbing is isolated from the frame with insulated hangers
- reduces sound transmission to the apartment

Airborne sound



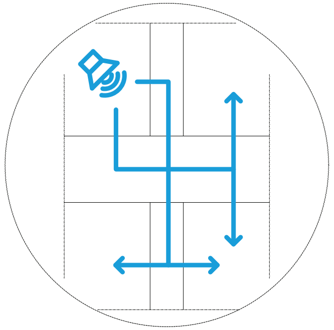
Direct sound path

acoustical design of structures according to local requirements

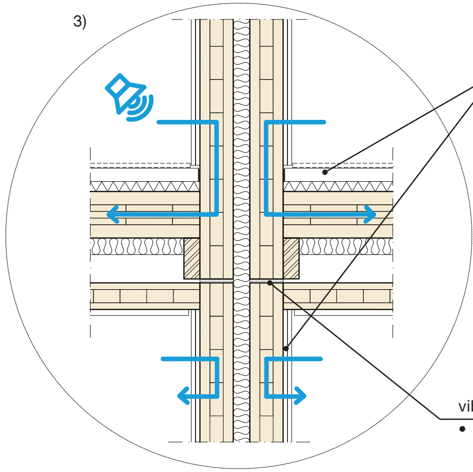


Direct sound path
The energy of airborne sound waves is reduced by the layered structure of the construction.

Flanking



Sound flanking path
When direct contact to the load-bearing frame

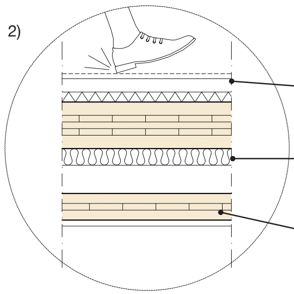


separated layer structures
- floor structures separated from the load-bearing frame
- separated wall structures for different apartments
- reduces flanking transmission to other apartments

vibration pad
- improves sound insulation and reduces flanking

Sound flanking path
When indirect contact to the load-bearing frame

Impact noise insulation

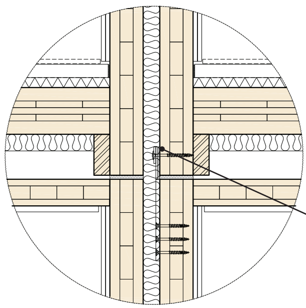


floating surface structure
- reduces impact sound

insulation
- sound absorption

separated load-bearing structures
- reduces flanking

Sound insulation in connections



all connections between separate apartments require vibration pads
- improves sound insulation and reduces flanking transmission

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4.4 Principles of fire design

Requirements on fire safety vary and depend on location, type and use of a building. Check that the specific requirements applying for your project comply with local and national regulations. Some basic principles for fire safety requirements are common across Europe:

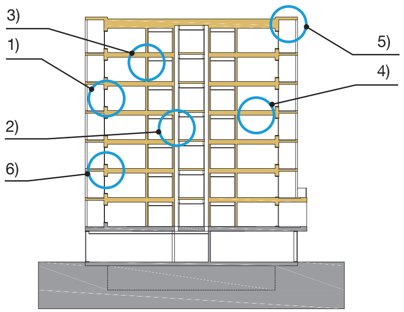
- occupants shall be able to leave the buildings or be rescued
- the safety of rescue teams shall be taken into account
- load-bearing structures shall resist fire for the required minimum duration of time
- the generation and spread of fire and smoke shall be limited
- the spread of fire to neighbouring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

According to these principles, building components must meet the following requirements:

- 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

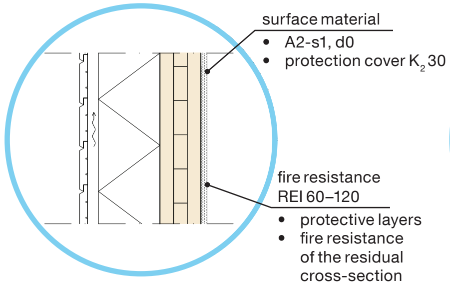
Principles concerning how to provide fire resistance with layups based on massive wood:

- 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

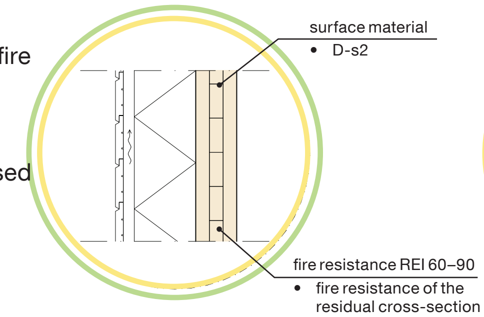


Fire safety of the load-bearing structures

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



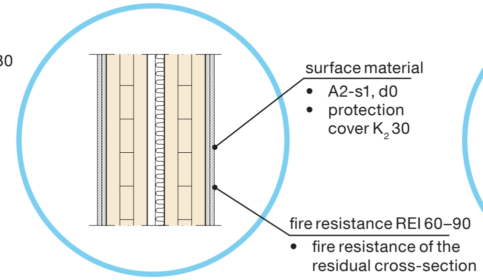
1) **Solid wall**



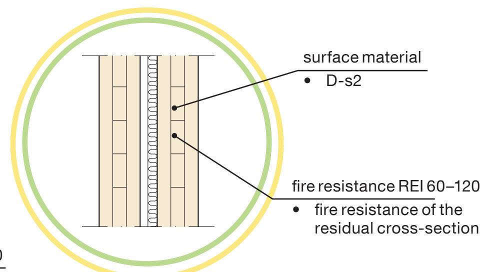
Example of fire safety detailing

Note national rules

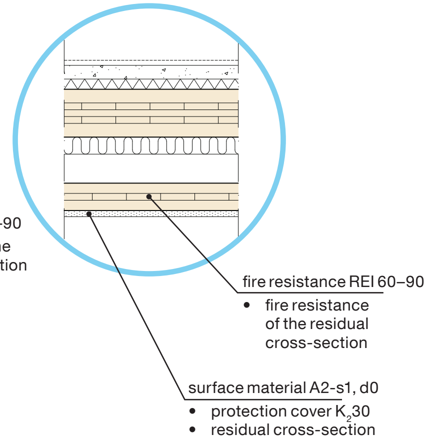
2) **Solid wall protected with surface layers**



2) **Solid wall**

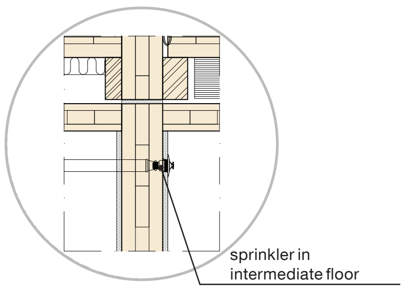


3) **Floor structure**

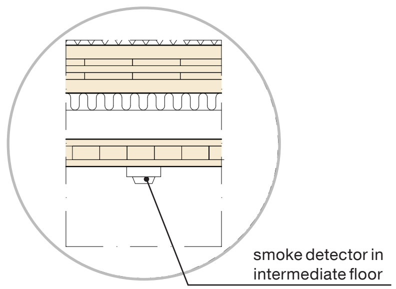


Extinguishing and rescue

4) **Sprinkler**



4) **Smoke detector**

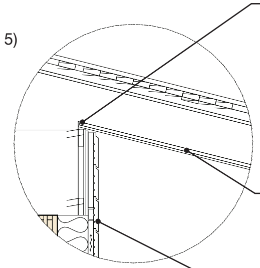


Example of fire safety detailing

Check compliance with national regulations

eave
(in case of pitched roof)

5)

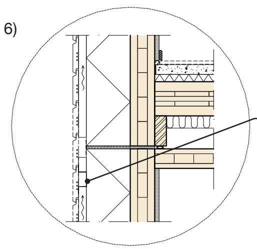


fire sealing
all joints need to be sealed

fire protection board

horizontal fire barrier
in ventilating slot
- fire barrier prevents fire from vertical fire spread in and on façades

6)



horizontal fire barrier
in ventilating slot
- fire barrier prevents fire from vertical fire spread in and on façades

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 7 stories and roof)
- span of floor: 4.4 m

Note: These are sample calculations and must be confirmed in a complete fire safety design.

1. Define the fire design loads (according EN 1990, EN 1991, EN 1995).

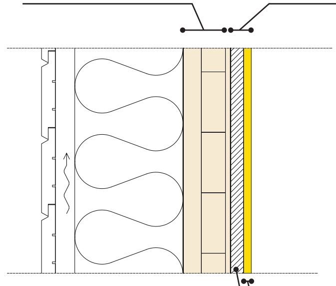
	4 stories		7 stories	
Wall mark	A	B	C	D
Total fire design load (kN/m)	117	217	194	357

2. Define the fire resistance of protective layers.

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

residual cross-section

60 / 90 min.



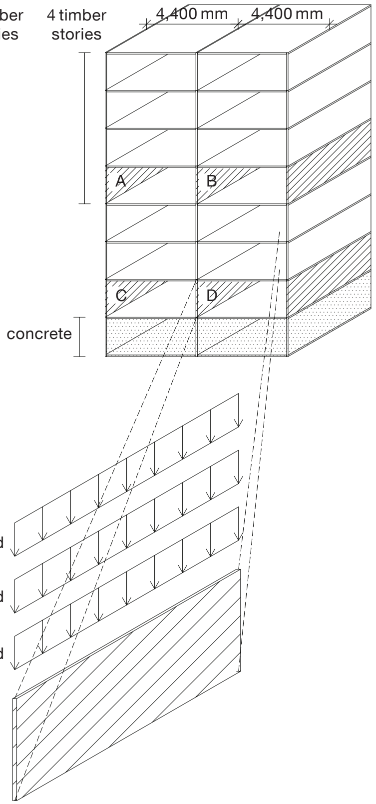
protective layer

charred layer

4. Load-bearing capacity of the residual cross-section with loads defined in (1) shall be calculated.

7 timber stories

4 timber stories



concrete

snow load

live load

dead load

4.5 Principles of controlling deformations and cracking

1. Deformations

Deformations derive from the material properties of timber and properties of the structural system. Dimensional changes are caused by moisture deformation, creeping and compression.

Swelling and shrinkage of wood

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.

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

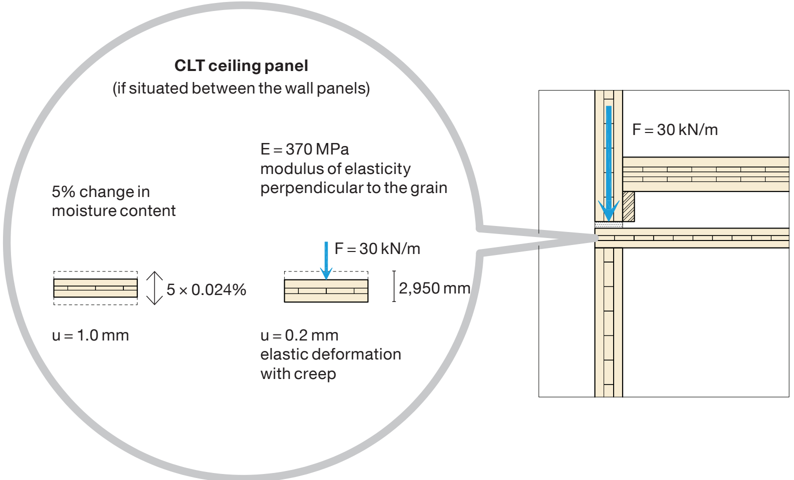
- perpendicular to the grain: 130-2400 MPa

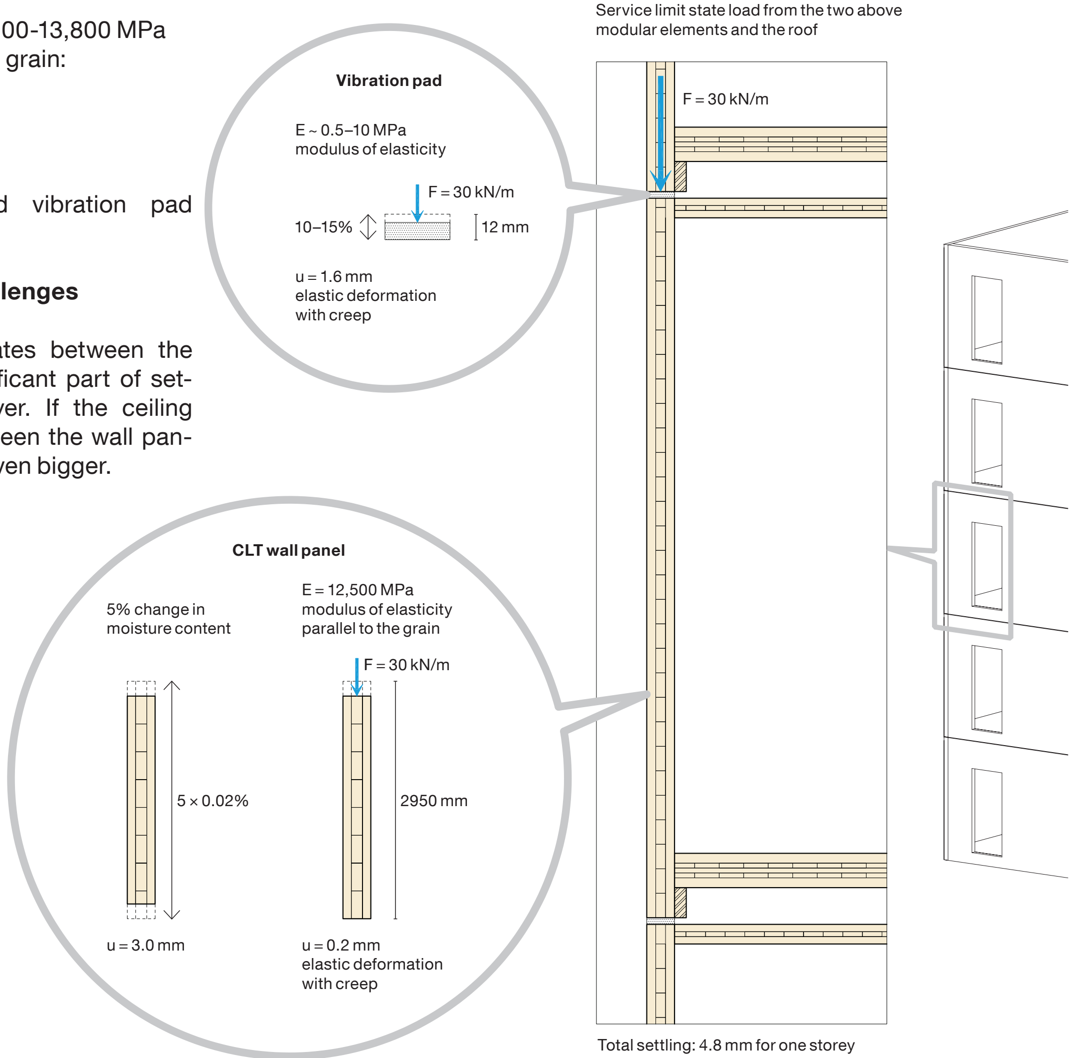
Creep and fatigue

Creep of timber and vibration pad increases settling.

Structural system challenges

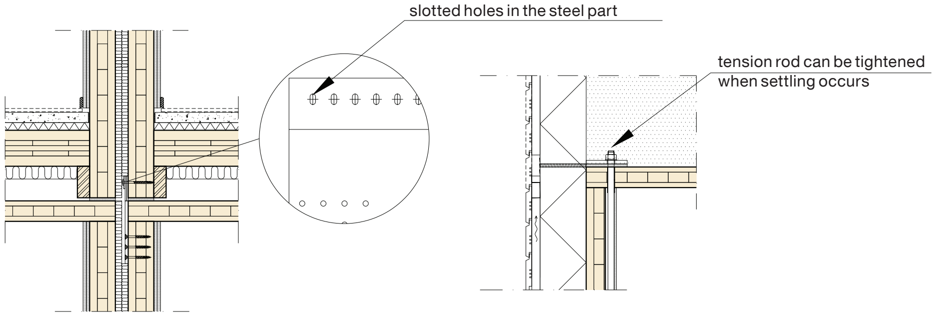
The vibration pad locates between the wall panels and a significant part of settling occurs in this layer. If the ceiling panel also locates between the wall panels, the deformation is even bigger.





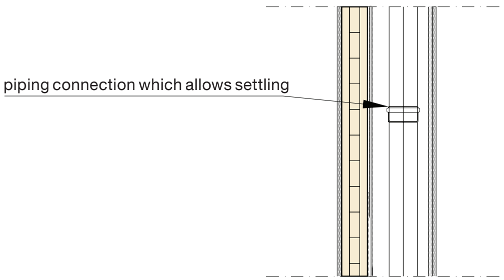
2. Connections

Deformations have to be considered when designing the connections. Deformations cause for example slotted holes to steel parts. Vertical deformation is the largest problem for uplift connections. When settling occurs, the tension rod loosens. It has to be retightened or there has to be a system which reduces the effects of the deformations.



3. HVAC

Settling has to be considered in vertical piping.

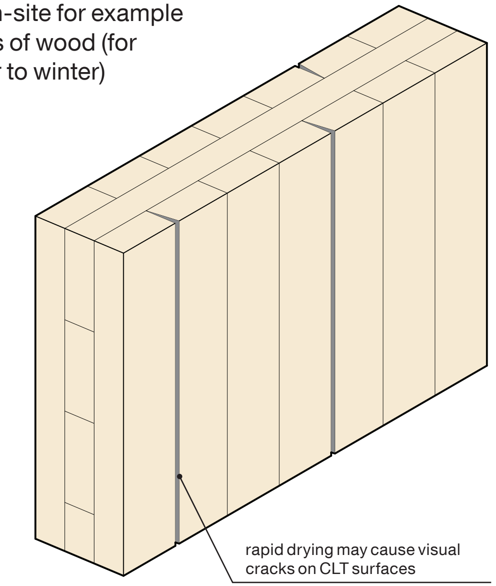


Cracking

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 the propagation of cracks:

- exceeding tension stresses due to uncontrolled drying on-site for example
- moisture deformations of wood (for example from summer to winter)



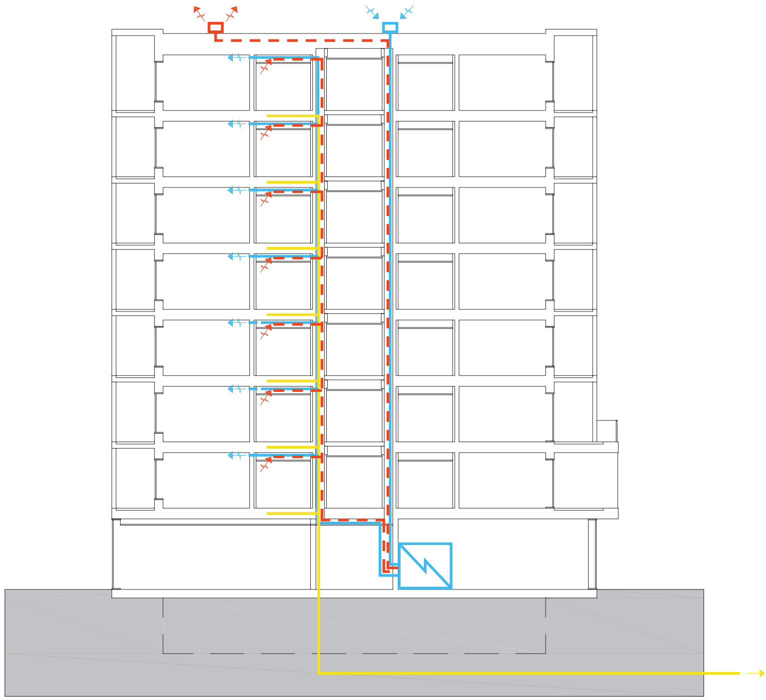
4.6 Principles of HVAC design

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

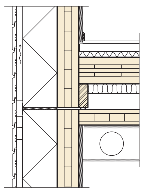
- fresh air
- exhaust air
- sewage



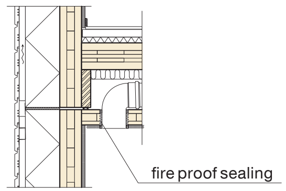
A – A

Options for pipe locations:

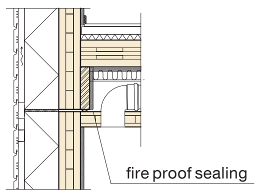
A) Pipes in suspended ceiling, fire compartment border in ceiling



B) Pipes between modular elements, fire compartment border in ceiling



C) Pipes between modular elements, fire compartment border in floor



Note: penetration through beams requires careful design

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4.7 Bracing systems of modular buildings

- Based on modular elements
- Local loadings, conditions and regulations must be considered

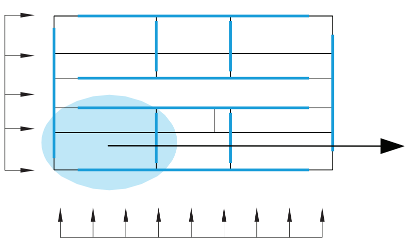
Guidelines for multistorey buildings

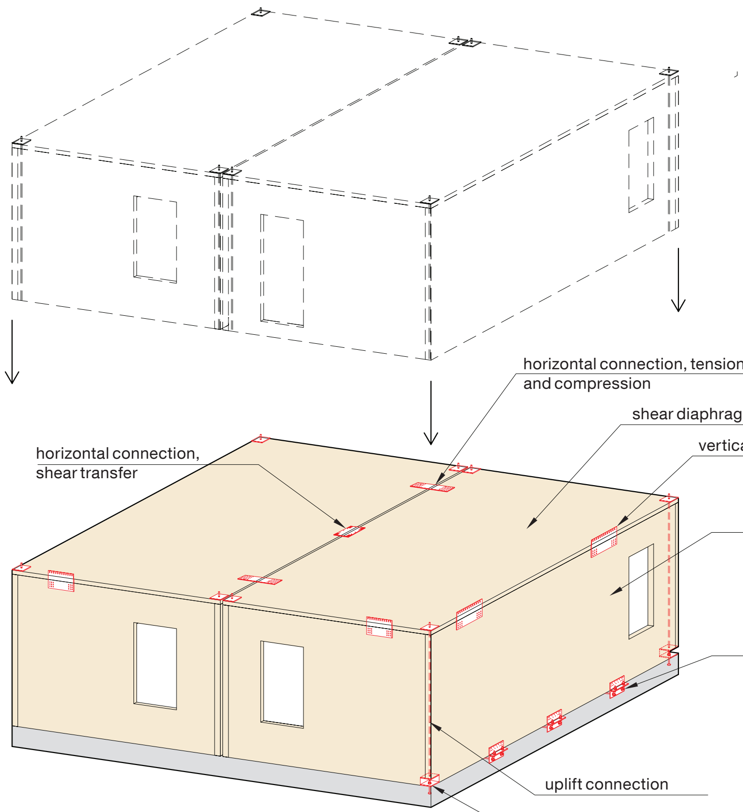
- Consult local loading conditions and building regulations
- Consider the layout and design of shear walls:
  - symmetrical floor layouts reduce torsional vibrations
  - sufficient numbers of walls insures overall stiffness
  - openings in shear walls must be carefully planned (size, location, number)

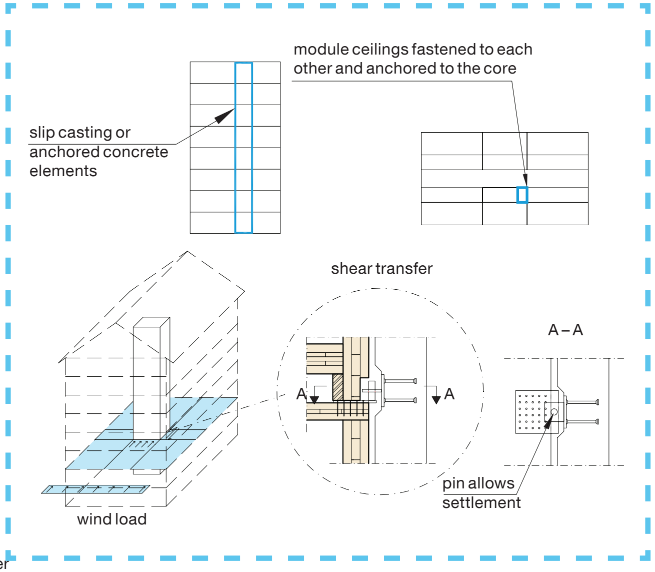
What calculations must consider

- Design loads
  - according to actual EN standard
  - particularly accidents (fire and progressive collapse) and seismic loads
- 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 with shear walls







Bracing with concrete core

4.8 Principles of seismic design

Conditions vary, but all buildings in seismic areas must be designed to resist seismic forces as required for their location and by the national regulations. The example building here can be built to resist seismic forces in accordance with Eurocode 8.

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 CLT modular 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
- type and class of the building (residential, class II)*
- structural system**

* 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.

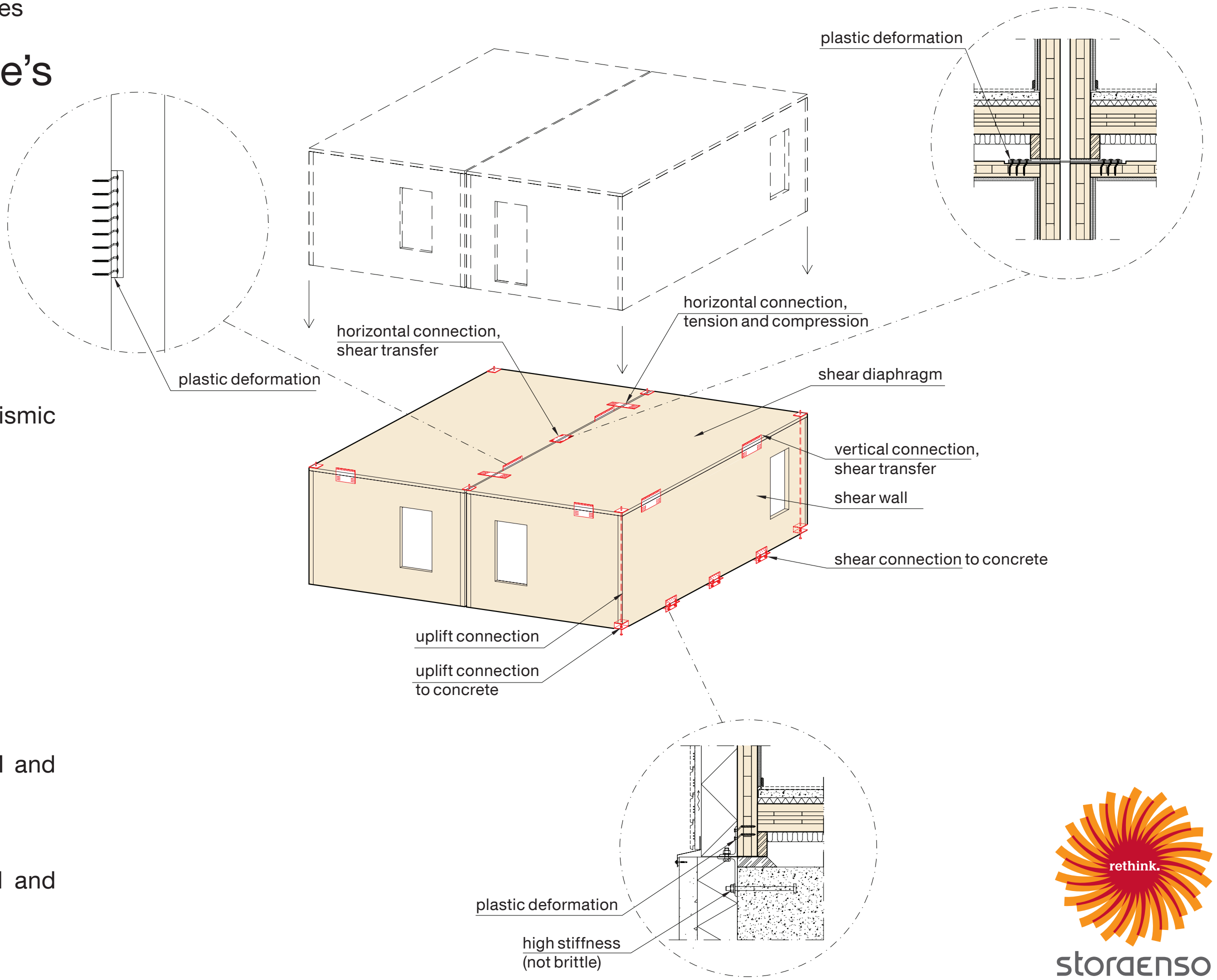
** Note that Stora Enso's CLT modular system has a light dead load and connections subject to plastic deformations.

Notes for details

a) connections have to be designed for seismic forces
b) no fractile joints (connectors should have enough slenderness)

Principles of seismic behavior of modular elements

- Modules remain as modules — no brittle fracture in internal connections
- Sufficient yielding capacity in connections between modules
- Forces are directed to stiffening structures with enough capacity to resist seismic forces
- Forces are directed to foundations — sufficient anchorage



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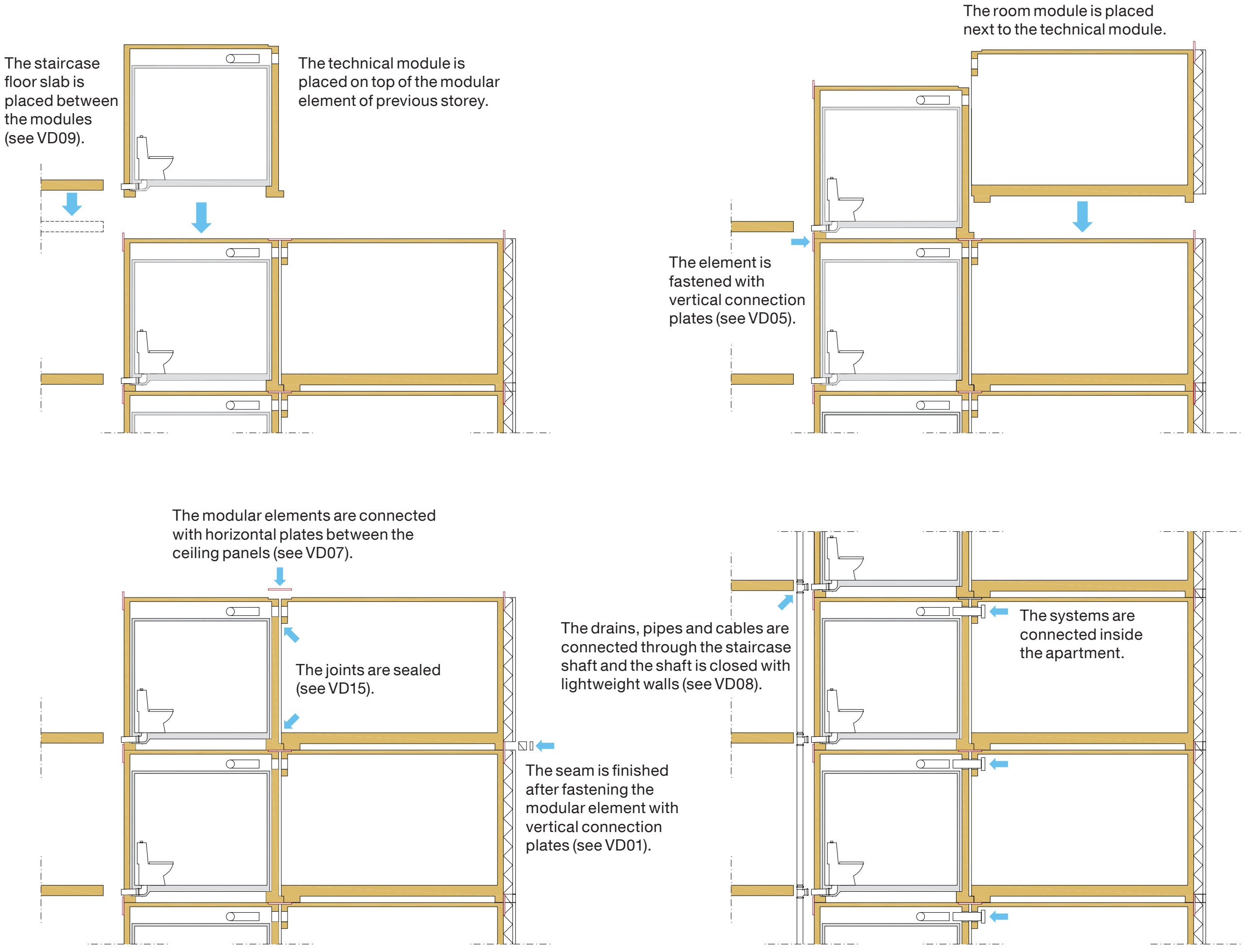
4.9 Erection procedure sequence

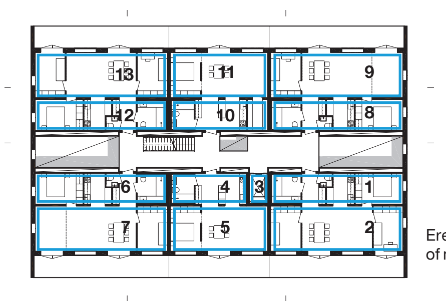
The erection procedure sequence has many effects on structural, architectural, HVAC and electrical wiring design. It has to be considered in the floor plan layout, pipe and cable routings as well as in the details.

The layout below illustrates the erection procedure sequence of the case study house. The erection advances one apartment at a time, starting from the technical module. The technical modules are situated next to the corridor to enable easy connections through the corridor shafts. When most of the building services equipment are included in the technical modules, the systems can easily be connected with short pipe and cable lines. When the technical installations are centralized in the corridor area, their maintenance is also easier, and complicated vertical shafts and connections can be avoided inside the apartments.

Particular attention must be paid to the erection procedure when designing connections. Connection hardware in the gap between two neighbouring modular units can be fastened only to the unit which is installed first, because the installation of the neighbouring modular unit blocks the access to the gap. Hence the erection procedure sequence affects where the connection hardware can be placed and which walls can function as shear walls.

It also has to be ensured that overhanging components are not in the way when positioning the modular units. Attention has to be paid to which components are placed on top of and in the middle of the others. In this case for instance, the technical module must be installed first, because the floor slab of the room module is laid upon the support on the side of the technical module.





Erection procedure sequence of modular elements (1–13)

5 Structural design

5.1 Structural types

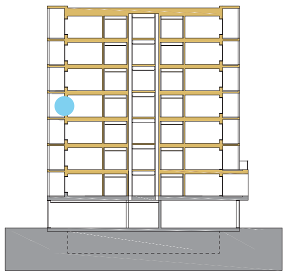
Orientation chart

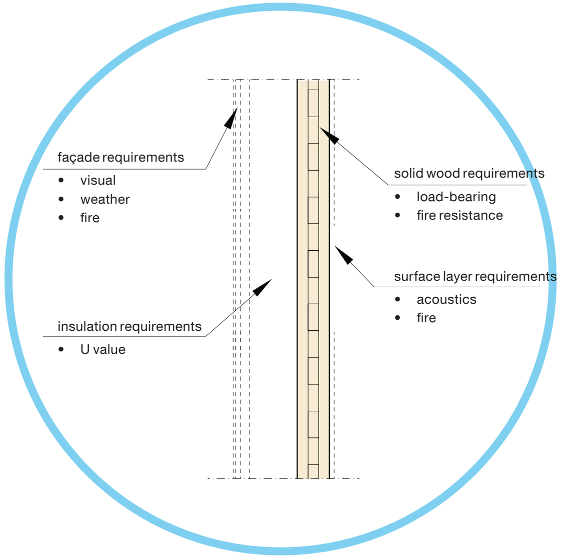
List of Drawings

Structural type	No.		Description
US	1		LOAD-BEARING EXTERNAL WALL
		A	Wood cladding, insulation, gypsum board
		B	Tile cladding, insulation, gypsum board
		C	Render, glass wool, visible CLT
		D	Render, wood fibre, visible CLT
		E	Wood cladding, insulation, visible CLT
VSK	1		LOAD-BEARING PARTITION WALL
		A	Double gypsum boards
		B	Visible CLT
VSK	2		LOAD-BEARING PARTITION WALL, BATHROOM
		A	Gypsum boards, waterproofing
		B	Sanitary box elements
VSK	3		LOAD-BEARING PARTITION WALL, ELEVATOR SHAFT
		A	CLT, gypsum boards
		B	CLT
		C	Concrete
VSK	4		LOAD-BEARING PARTITION WALL, CORRIDOR
		A	Lightweight inner partition (one side), double gypsum boards
		B	Lightweight inner partition (one side), gypsum boards
		C	Lightweight inner partition (one side), gypsum boards
		D	Lightweight inner partition (one side), service shaft
VSK	5		LOAD-BEARING PARTITION WALL, INSIDE APARTMENT
		A	Double CLT, gypsum boards
		B	CLT, gypsum boards
		C	Double column, gypsum boards
		D	Column, gypsum boards
VP	11		CLT SLAB INTERMEDIATE FLOOR, APARTMENT
		A	Floating floor slab, gypsum boards
		B	Floating floor slab, visible CLT
VP	2		CLT SLAB INTERMEDIATE FLOOR, BATHROOM
		A	Concrete slab, CLT, suspended ceiling
		B	Sanitary box element, CLT, sanitary box element
		C	Sanitary box element, CLT
VP	3		CLT SLAB INTERMEDIATE FLOOR, CORRIDOR
		A	Chipboard, CLT, suspended ceiling
		B	CLT, suspended ceiling
		C	CLT
		D	Floating floor slab, CLT, suspended ceiling
VP	41		CLT SLAB INTERMEDIATE FLOOR, BALCONY
		A	Open boarding, visible CLT
		B	Open boarding, suspended ceiling
VP	5		STAIRS
		A	CLT stairs, load-bearing CLT / gluelam
		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	Flat roof
YP	2		PITCHED ROOF; TIMBER TRUSS, CORRIDOR
		A	Timber truss roof, LVL bottom chord
AP	1		BASE FLOOR, CANTILEVER APARTMENT
		A	Floating floor slab, CLT
VS	1		NON-LOAD-BEARING PARTITION WALL, INSIDE APARTMENT
		A	Timber or steel frame
		B	CLT
VS	2		NON-LOAD-BEARING PARTITION WALL, INSIDE APARTMENT, BATHROOM
		A	Timber or steel frame, bathroom
		B	CLT, bathroom
E-VP	12		INTERMEDIATE FLOOR, APARTMENT
		A	Floating floor slab, rib slab, CLT
		B	Floating floor slab, timber joists, CLT, suspended ceiling
E-VP	42		CLT SLAB INTERMEDIATE FLOOR, RECESSED BALCONY, APARTMENT
		A	Floating floor slab, visual CLT
E-VSK	12		LOAD-BEARING PARTITION WALL, RECESSED BALCONY, APARTMENT
		A	Wood cladding, double CLT, gypsum boards

US 1

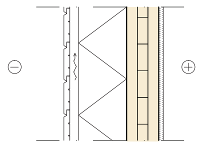
Load-bearing external wall





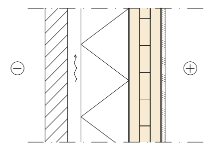
Variables

A. Wood cladding, insulation, gypsum board



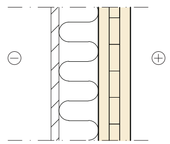
Structure
- façade material
- ventilation [32 mm]
- insulation*
- CLT [120 mm]**
- gypsum board [18 mm]*

B. Tile cladding, insulation, gypsum board



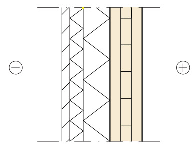
Structure
- façade material
- ventilation [50 mm]
- insulation*
- CLT [120 mm]**
- gypsum board [18 mm]*

C. Render, glass wool, visible CLT



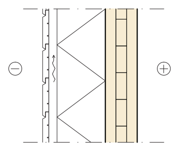
Structure
- render [10–30 mm]
- mineral wool insulation*
- CLT [120 mm]**

D. Render, wood fibre, visible CLT



Structure
- render [10–30 mm]
- timber frame + wood fibre insulation [150 mm]
- CLT [120 mm]**

E. Wood cladding, insulation, visible CLT



Structure
- façade material*
- ventilation [32 mm]
- insulation [180 mm]
- CLT [120 mm]**

* variable
** according to structural calculations

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 120)	Minimum CLT cross-section				U [W/m²K]	Surface reaction to fire		R_w (C; C_{tr}) [dB]
				R60		R90					
				4 floors	7 floors	4 floors	7 floors		Inner	Outer	
A.0	180 mm	gypsum board [18 mm]	373 mm	120 C3s	120 C3s	140 C5s	140 C5s	0.153	A2-s1,d0	D-s2, d0	44 (0; –2)
A.1	120 mm	gypsum board [18 mm]	313 mm	120 C3s	120 C3s	140 C5s	140 C5s	0.211	A2-s1,d0	D-s2, d0	44 (0; –2)
A.2	180 mm	wood based panel	369 mm	–	–	–	–	0.152	–	D-s2, d0	44 (0; –3)
B.0	180 mm	gypsum board [18 mm]	453 mm	120 C3s	120 C3s	140 C5s	140 C5s	0.153	A2-s1,d0	–	54 (–1; –3)
B.1	120 mm	gypsum board [18 mm]	393 mm	120 C3s	120 C3s	140 C5s	140 C5s	0.211	A2-s1,d0	–	54 (–1; –3)
B.2	180 mm	wood based panel	449 mm	–	–	–	–	0.152	–	–	54 (–1; –3)
B.3	180 mm	visible CLT	393 mm	140 C5s	140 C5s	140 C5s	140 C5s	0.154	D-s2, d0	–	54 (–2; –4)
C.0	150 mm	visible CLT	298 mm	140 C5s	140 C5s	140 C5s	140 C5s	0.196	D-s2, d0	–	44 (0; –3)
C.1	180 mm	visible CLT	328 mm	140 C5s	140 C5s	140 C5s	140 C5s	0.169	D-s2, d0	–	44 (0; –3)
D.0	150 mm	visible CLT	300 mm	140 C5s	140 C5s	140 C5s	140 C5s	0.232	D-s2, d0	–	39 (0; –3)
E.0	180 mm	visible CLT	355 mm	140 C5s	140 C5s	140 C5s	140 C5s	0.154	D-s2, d0	D-s2, d0	42 (0; –3)

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

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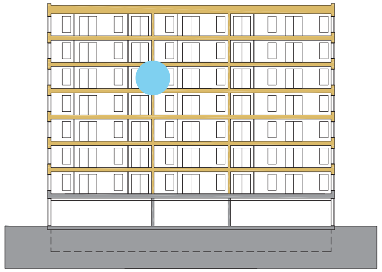
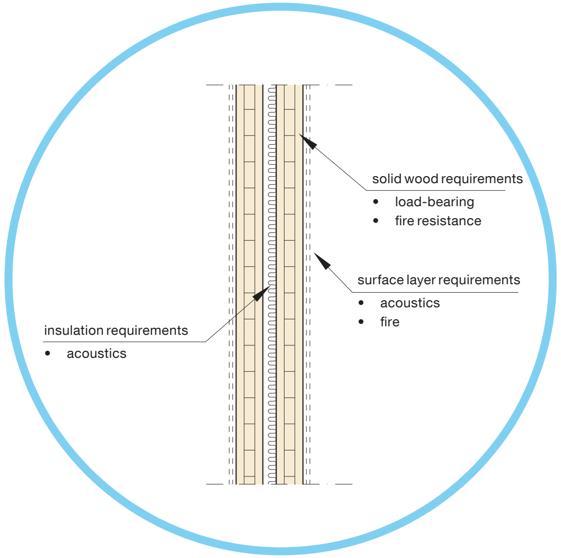
VSK 1

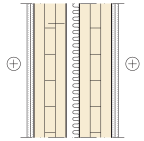
Load-bearing partition wall





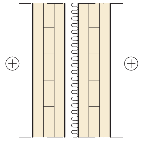
Variables

A. Double gypsum boards



Structure
- 2 gypsum boards [13 mm]
- CLT [120 mm]**
- air gap [50 mm] + insulation [30 mm]
- CLT [120 mm]**
- 2 gypsum boards [13 mm]

B. Visible CLT



Structure
- CLT [120 mm]**
- air gap [50 mm] + insulation [30 mm]
- CLT [120 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.

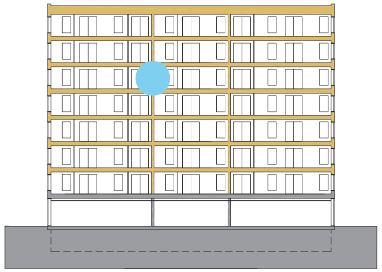
Type	Insulation	Materials	Thickness (CLT 120)	Minimum CLT cross-section				Surface reaction to fire	R_w (C; C_{tr}) [dB]
				R60		R90			
				4 floors	7 floors	4 floors	7 floors		
A.0	30 mm	gypsum boards [2 × 13 mm]	342 mm	140 C5s	140 C5s	140 C5s	140 C5s	A2-s1,d0	56 (–1; –5)
A.1	30 mm	wood based panel	344 mm	–	–	–	–	D-s2, d0	–
B.0	30 mm	CLT	290 mm	140 C5s	140 C5s	140 C5s	140 C5s	D-s2, d0	–

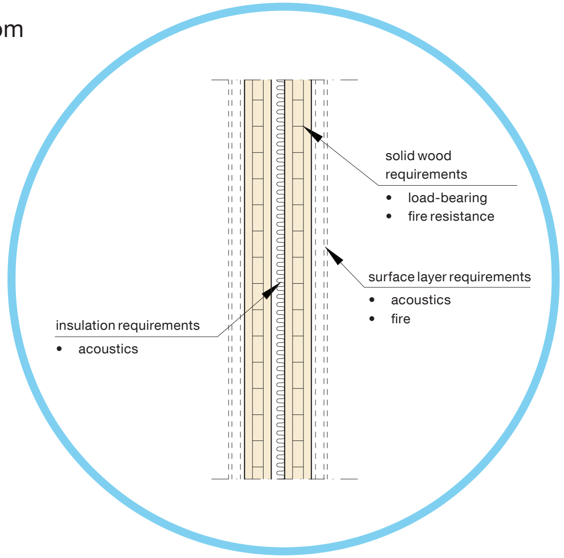
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

VSK 2

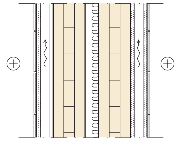
Load-bearing partition wall, bathroom





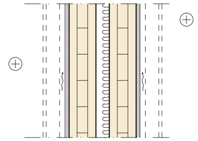
Variables

A. Gypsum boards, waterproofing



Structure
- tiles
- tile adhesive
- certified waterproofing system
- wet area board [13 mm]
- battens [32 mm] + air gap
- gypsum board [15 mm]
- CLT [120 mm]**
- air gap [50 mm] + insulation [30 mm]
- CLT [120 mm]**
- gypsum board [15 mm]
- battens [32 mm] + air gap
- wet area board [13 mm]
- certified waterproofing system
- tile adhesive
- tiles

B. Sanitary box elements



Structure
- sanitary box element
- air gap
- gypsum board [15 mm]
- CLT [100 mm]**
- air gap [50 mm] + insulation [30 mm]
- CLT [100 mm]**
- gypsum board [15 mm]
- air gap
- sanitary box element

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 120)	Minimum CLT cross-section				Surface reaction to fire	R_w (C; C_{tr}) [dB]
				R60		R90			
				4 floors	7 floors	4 floors	7 floors		
A.0	30 mm	tiles	434	120 C3s	120 C3s	140 C5s	140 C5s	–	60 (–3 ; –9)
B.0	30 mm	sanitary box element	444	120 C3s	120 C3s	140 C5s	140 C5s	–	54 (–2; –5)

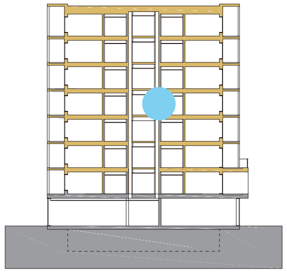
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

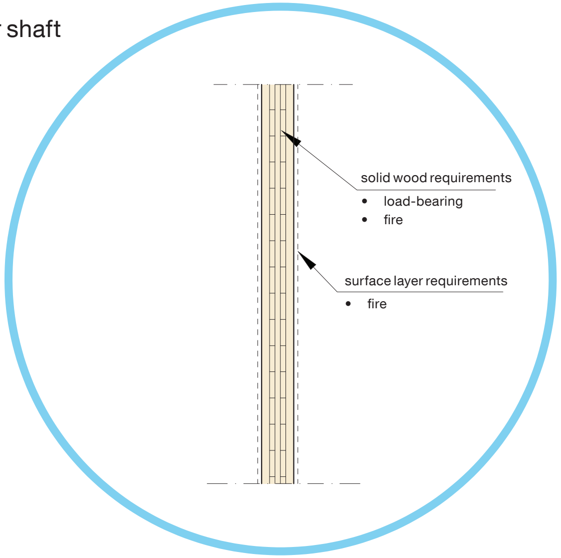
* variable
** according to structural calculations

rethink.
storaenso

VSK 3

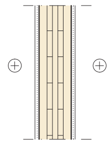
Load-bearing partition wall, elevator shaft





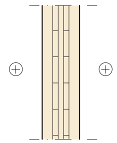
Variables

A. CLT, gypsum boards



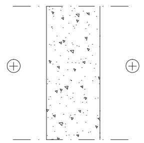
Structure
- gypsum board* [15 mm]
- CLT [120 mm]**
- gypsum board* [15 mm]

B. CLT



Structure
- CLT** [140 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.

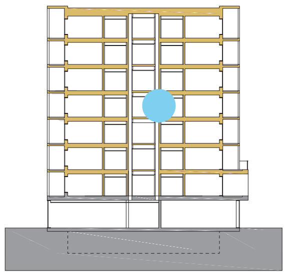
Type	Insulation	Surface material	Thickness (CLT 120/140)	Fire resistance	Surface reaction to fire	Charring		R_w (C; C_{tr}) [dB]
						R60	R90	
A.0	–	gypsum board [15 mm]	150 mm	R30	A2-s1,d0	–		37 (–1; –4)
A.1	–	wood based panel	148 mm	–	–	–		36 (0; –3)
B.0	–	CLT	140 mm	–	D-s2, d0	–		36 (–1; 4)
C.0	–	concrete	200 mm	–	–	–		59 (–2; –5)

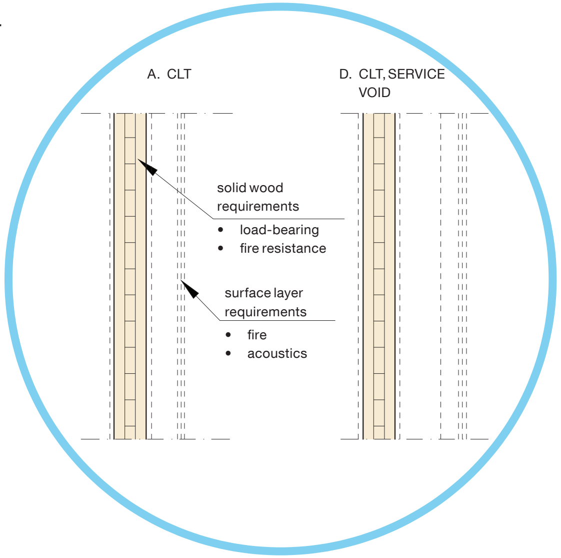
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

VSK 4

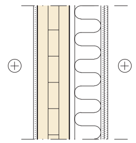
Load-bearing partition wall, corridor





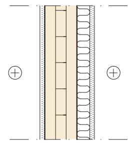
Variables

A. Lightweight inner partition (one side), double gypsum boards



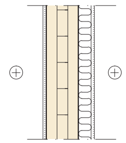
Structure
- gypsum board * [15 mm]
- CLT [120 mm]**
- air gap [20 mm] + punctual fastening
- timber frame wall [98 mm] + insulation [100 mm]
- 2 gypsum boards [13 mm]

B. Lightweight inner partition (one side), gypsum boards



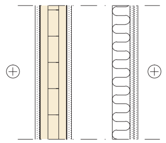
Structure
- gypsum board [18 mm]*
- CLT [120 mm]**
- battens [48 mm] + insulation [50 mm]
- gypsum board [18 mm]

C. Lightweight inner partition (one side), plasterboards



Structure
- plasterboard [13 mm]
- CLT [120 mm]**
- battens [48 mm] + insulation [50 mm]
- plasterboard [13 mm]

D. Lightweight inner partition (one side), service shaft



Structure
- gypsum board [18 mm]*
- CLT [120 mm]**
- gypsum board [18 mm]
- air gap
- steel frame + insulation [50 mm]
- 2 gypsum boards [15 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.

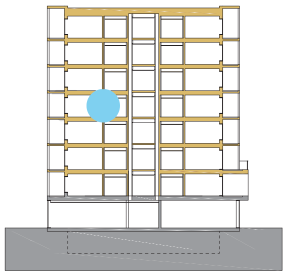
Type	Insulation	Materials	Thickness (CLT 120)	Minimum CLT cross-section				Surface reaction to fire	R_w (C; C_{tr}) [dB]
				R60		R90			
				4 floors	7 floors	4 floors	7 floors		
A.0	100 mm	gypsum board [15 mm / 13 mm]	279 mm	140 C5s	140 C5s	140 C5s	140 C5s	A2-s1,d0	61 (–1; –5)
A.1	100 mm	wood based panel / gypsum board [13 mm]	278 mm	–	–	–	–	D-s2, d0/A2-s1,d0	–
A.2	100 mm	visible CLT / gypsum board [13 mm]	264 mm	140 C5s	140 C5s	140 C5s	140 C5s	D-s2, d0/A2-s1,d0	–
B.0	50 mm	gypsum board [18 mm]	204 mm	120 C3s	120 C3s	140 C5s	140 C5s	A2-s1,d0	–
B.1	50 mm	wood based panel / gypsum board [18 mm]	200 mm	–	–	–	–	D-s2, d0/A2-s1,d0	–
B.2	50mm	visible CLT / gypsum board [18 mm]	186 mm	140 C5s	140 C5s	140 C5s	140 C5s	D-s2, d0/A2-s1,d0	–
C.0	50 mm	plasterboards [13 mm]	194 mm	140 C5s	140 C5s	140 C5s	140 C5s	A2-s1,d0	–
D.0	50 mm	gypsum board [18 mm / 2 × 15 mm]	385 mm	120 C3s	120 C3s	140 C5s	140 C5s	A2-s1,d0	–
D.1	50 mm	wood based panel / gypsum boards [2 × 15 mm]	381 mm	–	–	–	–	D-s2, d0/A2-s1,d0	–
D.2	50 mm	visible CLT / gypsum boards [2 × 15 mm]	377 mm	140 C5s	140 C5s	140 C5s	140 C5s	D-s2, d0/A2-s1,d0	–

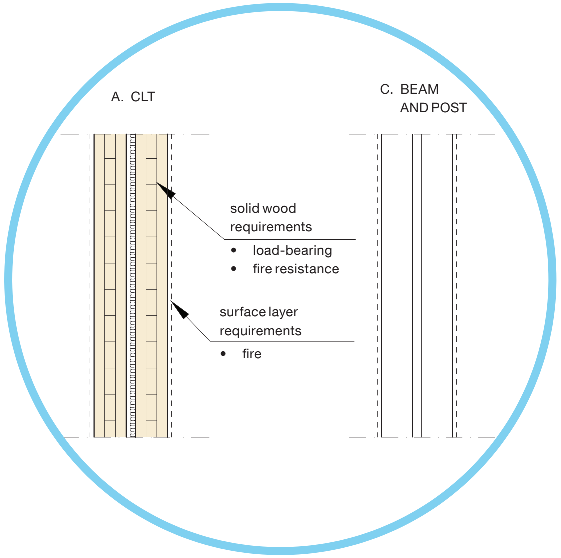
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

VSK5

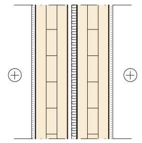
Load-bearing partition wall, inside apartment





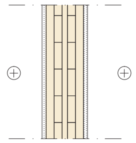
Variables

A. Double CLT, gypsum boards



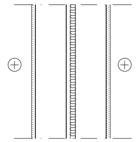
Structure
- gypsum board* [15 mm]
- CLT [120 mm]**
- air gap [35 mm] + insulation
- CLT [120 mm]**
- gypsum board* [15 mm]

B. CLT, gypsum boards



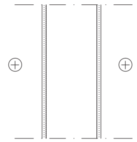
Structure
- gypsum board* [15 mm]
- CLT [140 mm]**
- gypsum board* [15 mm]

C. Double column, gypsum boards



Structure
- gypsum board [15 mm]
- gluelam column [115 mm]**
- air gap [35 mm] + insulation
- gluelam column [115 mm]**
- gypsum board [15 mm]

D. Column, gypsum boards



Structure
- gypsum board [15 mm]
- gluelam column [190 mm]**
- gypsum board [15 mm]

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

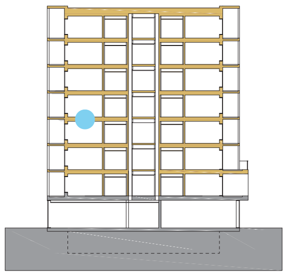
Type	Insulation	Materials	Thickness	Minimum CLT cross-section				Surface reaction to fire	R_w (C; C_{tr}) [dB]
				R60		R90			
				4 floors	7 floors	4 floors	7 floors		
A.0	20 mm	gypsum board [15 mm]	305 mm	120 C3s	120 C3s	140 C5s	140 C5s	A2-s1,d0	54 (–2; –6)
	20 mm	wood based panel	303 mm	–	–	–	–	D-s2, d0	53 (–1; –5)
	20 mm	visible CLT	275 mm	140 C5s	140 C5s	140 C5s	140 C5s	D-s2, d0	52 (–1; –6)
B.0	–	gypsum board [15 mm]	170 mm	160 C5s	160 C5s	–	–	A2-s1,d0	38 (–1; –4)
		wood based panel	168 mm	–	–	–	–	D-s2, d0	38 (–1; –5)
		visible CLT	140 mm	–	–	–	–	D-s2, d0	36 (–1; 4)
C.0	20 mm	gypsum board [15 mm]	295 mm	–	–	–	–	A2-s1,d0	51 (–2; –7)
D.0	–	gypsum board [15 mm]	220 mm	–	–	–	–	A2-s1,d0	40 (–3; –10)

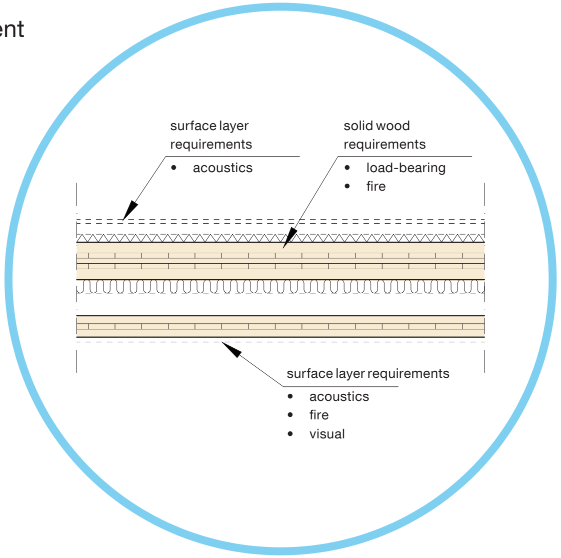
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

VP 11

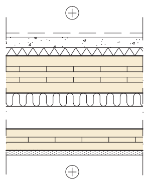
CLT slab intermediate floor, apartment





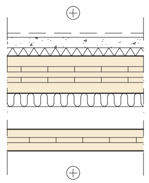
Variables

A. Floating floor slab, gypsum board



Structure
- surface layer
- floating floor slab [40 mm]
- impact sound isolation [30 mm]
- CLT [140 mm]**
- air gap [135 mm] + insulation [50 mm]
- CLT [80 mm]**
- gypsum board [18 mm]

B. Floating floor slab, visible CLT



Structure
- surface layer
- floating floor slab [40 mm]
- impact sound isolation [30 mm]
- CLT [140 mm]**
- air gap [135 mm] + insulation [50 mm]
- CLT [80 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.

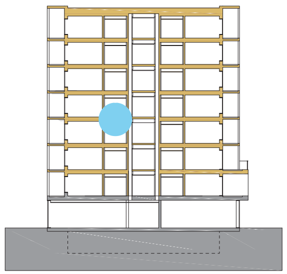
Type	Insulation	Surface material	Thickness	Fire resistance	Surface reaction to fire		Charring		R_w (C; C_{tr}) [dB]	$L_{n,w}$ (C_I) [dB]
					Floor	Ceiling	R60	R90		
A.0	50 mm	floor slab [40 mm] / gypsum board [18 mm]	458 mm	REI 60	–	A2-s1,d0	16 mm	36 mm	62 (–1; –5)	74 (–10)
B.0	50 mm	floor slab [40 mm] / CLT	440 mm	–	–	D-s2, d0	25 mm	45 mm	61 (–1; –5)	75 (–10)

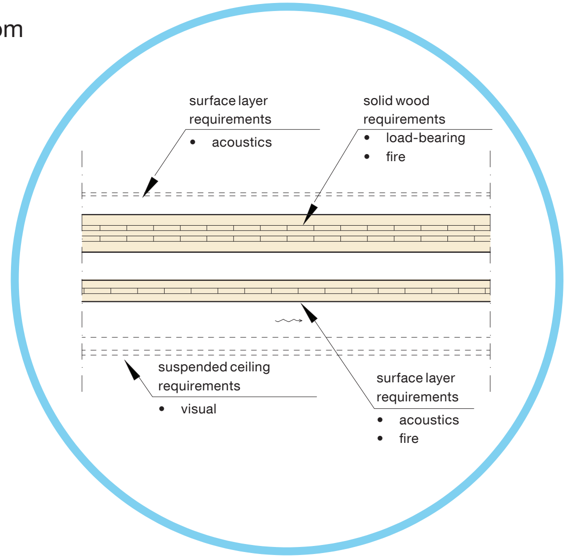
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

VP 2

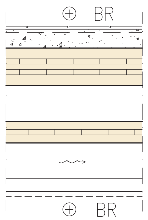
CLT slab intermediate floor, bathroom





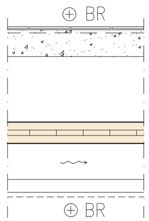
Variables

A. Concrete slab, CLT, suspended ceiling



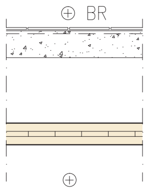
Structure
- tiles
- tile adhesive
- certified waterproofing system
- concrete slab [70 mm]
- CLT [140 mm]**
- air gap [135 mm]
- CLT [80 mm]**
- drop ceiling and panelling

B. Sanitary box element, CLT, sanitary box element



Structure
- tiles
- tile adhesive
- certified waterproofing system
- concrete slab [100 mm]
- air gap [245 mm]
- CLT [80 mm]**
- drop ceiling and panelling

C. Sanitary box element, CLT



Structure
- tiles
- tile adhesive
- certified waterproofing system
- concrete slab [100 mm]
- air gap [245 mm]
- CLT [80 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.

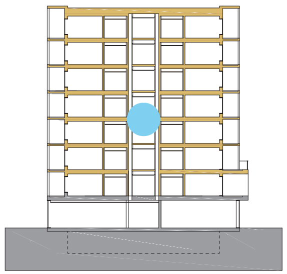
Type	Insulation	Surface material	Thickness	Fire resistance	Surface reaction to fire		Charring		R_w (C; C_{tr}) [dB]	$L_{n,w}$ (C_I) [dB]
					Floor	Ceiling	R60	R90		
A.0	100 mm	tiles / CLT	637 mm	REI 60	–	D-s2, d0	25 mm	45 mm	66 (–2; –6)	71 (–10)
B.0	30 mm	tiles / CLT	637 mm	REI 60	–	D-s2, d0	–	–	71 (–2; –6)	67 (–10)
C.0	30 mm	tiles / CLT	437 mm	REI 60	–	D-s2, d0	–	–	53 (–2; –7)	75 (–9)

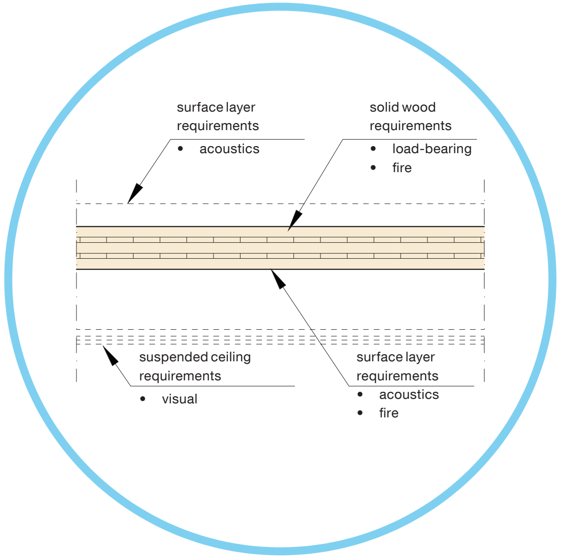
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

VP 3

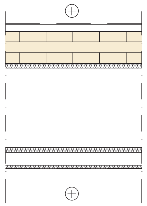
CLT slab intermediate floor, corridor





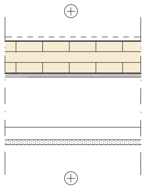
Variables

A. Chipboard, CLT, suspended ceiling



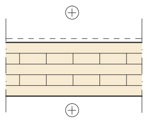
Structure
- surface layer
- chipboard [25 mm]
- CLT [120 mm]**
- gypsum board [18 mm]
- Supporting gluelam beams
- gypsum board [18 mm]
- suspended ceiling and gypsum board [13 mm]

B. CLT, suspended ceiling



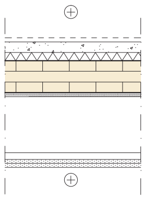
Structure
- surface layer
- CLT [120 mm]**
- gypsum board [15 mm]
- suspended ceiling and gypsum board [18 mm]

C. CLT



Structure
- surface layer
- CLT [200 mm]**

D. Floating floor slab, CLT, suspended ceiling



Structure
- surface layer
- floating floor slab [40 mm]
- impact sound isolation [30 mm]
- CLT [120 mm]**
- gypsum board [15 mm]
- suspended ceiling
- resilient channel [25 mm]
- gypsum board [2 × 15 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.

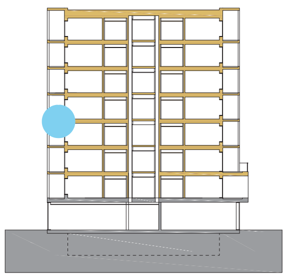
Type	Insulation	Surface material	Thickness	Fire resistance	Surface reaction to fire		Charring		R_w (C; C_{tr}) [dB]	$L_{n,w}$ (C_i) [dB]
					Floor	Ceiling	R60	R90		
A.0	–	chipboard / gypsum board [13 mm]	544 mm	REI 60	–	A2-s1,d0	0 mm	30 mm	59 (–2; –8)	55 (1)
B.0	–	CLT / gypsum board [18 mm]	403 mm	–	–	A2-s1,d0	8 mm	39 mm	43 (0; –3)	72 (–8)
C.0	–	CLT	215 mm	–	–	D-s2, d0	46 mm	65 mm	41 (–2; –6)	84 (–8)
D.0	30 mm	floor slab [40 mm] / gypsum board [15 mm]	485 mm	REI 60	–	A2-s1,d0	0 mm	24 mm	61 (–2; –8)	70 (–6)

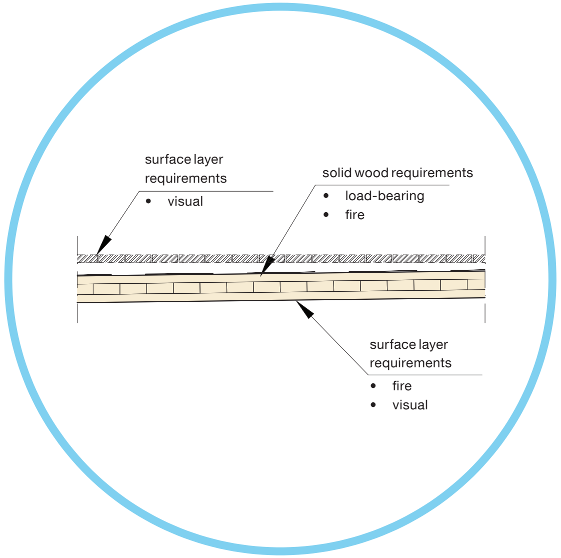
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

VP 41

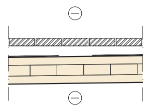
CLT slab intermediate floor, balcony





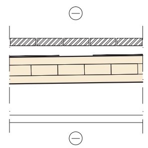
Variables

A. Open boarding, visible CLT



Structure
- open boarding [28 mm]
- firring piece
- waterproofing
- CLT [100 mm]**
- fire retardant treatment

B. Open boarding, suspended ceiling



Structure
- open boarding [28 mm]
- firring piece
- waterproofing
- CLT [100 mm]**
- fire retardant treatment
- suspended ceiling
- boarding [28 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.

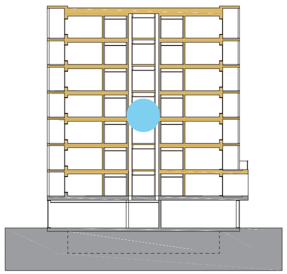
Type	Insulation	Surface material	Thickness	Fire resistance	Surface reaction to fire		Charring		R_w (C; C_{tr}) [dB]	$L_{n,w}$ (C_I) [dB]
					Floor	Ceiling	R60	R90		
A.0	–	boarding / fire retardant treatment	170 mm	REI 30	–	B-s2.d0	30 mm	45 mm		
B.0	–	boarding / fire retardant treatment	317 mm	REI 30	–	B-s2.d0	30 mm	45 mm		

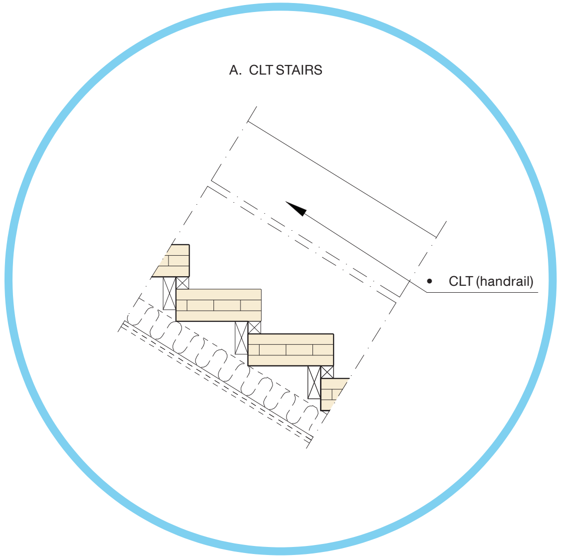
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

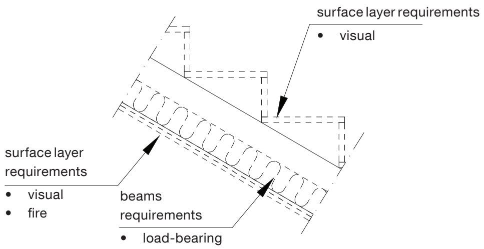
VP 5

Stairs



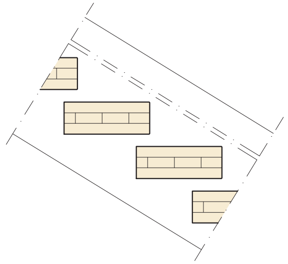


B. NAIL PLATE STRUCTURED STAIRS



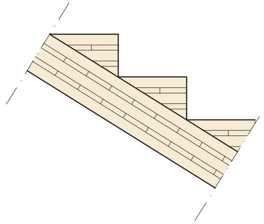
Variables

A. CLT stairs, load-bearing CLT / gluelam



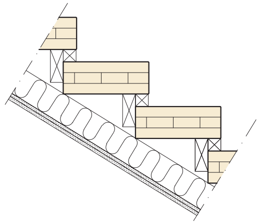
Structure
- CLT steps
- load-bearing CLT handrails or gluelam beams

B. CLT stairs, CLT slab



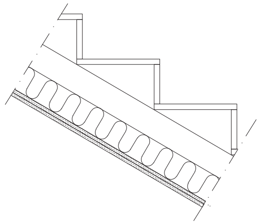
Structure
- CLT steps
- CLT slab**

C. CLT steps, gluelam beams, insulation



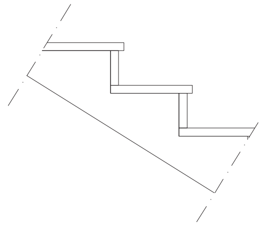
Structure
- CLT steps
- supporting beams for CLT steps and load-bearing CLT handrails**
- insulation [100 mm]
- gypsum board [2 × 13 mm]

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.

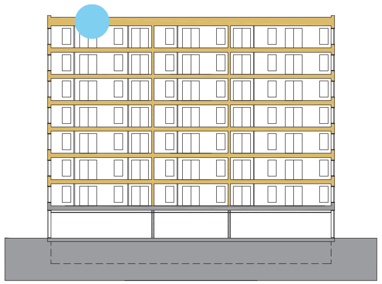
Type	Insulation	Surface material	Thickness	Fire resistance	Surface reaction to fire		R_w (C; C_{tr}) [dB]	$L_{n,w}$ (C_i) [dB]
					Floor	Ceiling		
A.0	0 mm	CLT	–	–	–	D-s2, d0	–	–
B.0	0 mm	CLT	160 mm	–	–	D-s2, d0	44 (–1; –5)	82 (–7)
C.0	100 mm	CLT / gypsum board [2 × 13 mm]	226 mm	REI 30	D_{FL}-s1	A2-s1,d0	41 (–1; –4)	73 (–8)
D.0	100 mm	plywood / gypsum board [2 × 13 mm]	198 mm	REI 30	D_{FL}-s1	A2-s1,d0	44 (–4; –12)	75 (–4)
E.0	0 mm	concrete	110 mm	–	–	–	50 (–1; –3)	50 (–1; –3)

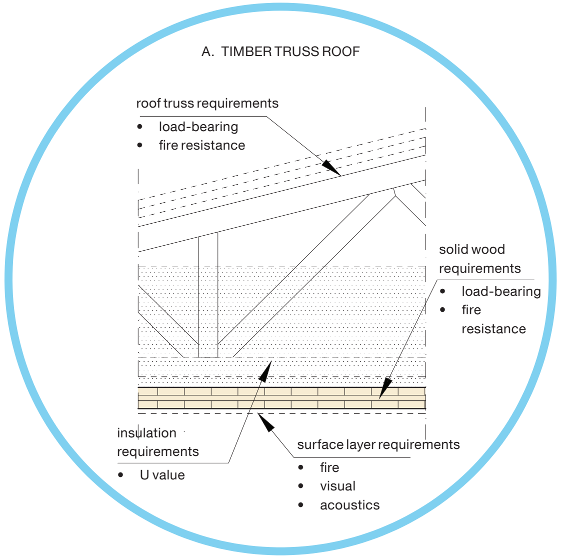
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

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

YP 1

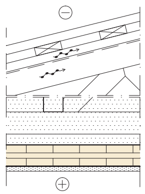
Roof structure





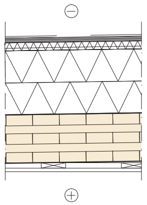
Variables

A. Timber truss roof



Structure
- roof material
- roof batten + ventilation batten
- roof underlayment
- roof truss + ventilation
- insulation [450 mm]
- CLT [80 mm]
- gypsum board [18 mm]

B. Flat roof



Structure
- bitumen sheet
- plywood board
- rock wool with ventilation channel
- polyurethane insulation board
- moisture barrier
- CLT [180 mm]**
- battens
- gypsum board [13 mm]

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

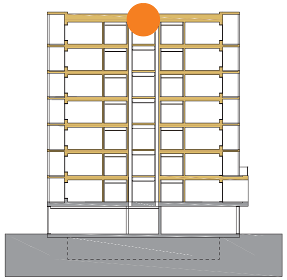
Type	Insulation	Surface material	Thickness	Fire resistance	U [W/m²K]	Surface reaction to fire		R_w (C; C_{tr}) [dB]
						Roof	Ceiling	
A.0	450 mm	gypsum board [18 mm]	–	REI 60	0.076	B_{ROOF}	A2-s1,d0	42 (0; –2)
B.0	270 mm	gypsum board [13 mm]	–	–	–	–	A2-s1,d0	60 (–1; –5)

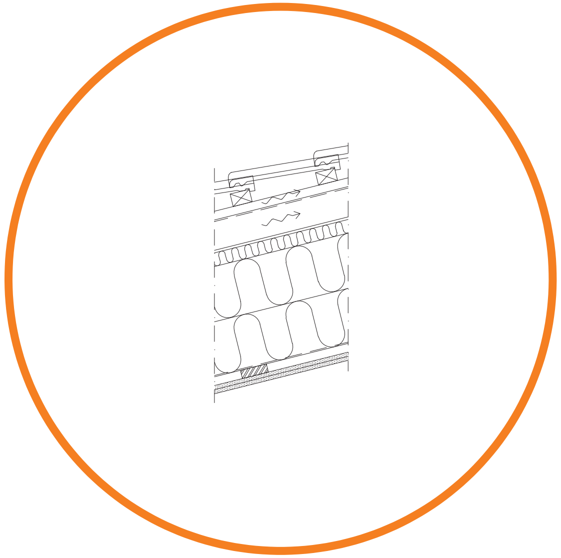
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

YP 2

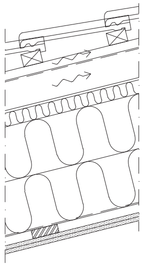
Pitched roof, timber truss, corridor





Variables

A. 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
- battens [32 mm]
- 2 gypsum boards [15 mm]

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

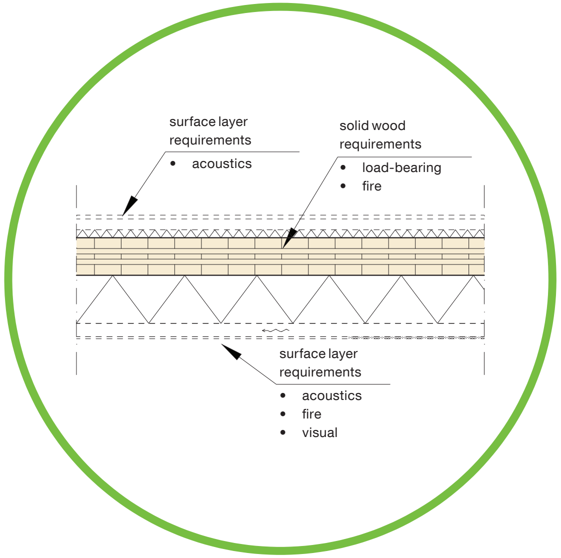
Type	Insulation	Surface material	Thickness	Fire resistance	U [W/m²K]	Surface reaction to fire		R_w (C; C_{tr}) [dB]
						Roof	Ceiling	
A.0	450 mm	gypsum boards [2 × 15 mm]	–	REI 60	0.076	–	A2-s1,d0	58 (–1; –5)

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

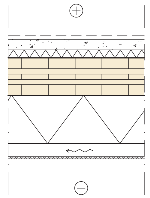
AP 1

Base floor, cantilever apartment



Variables

A. Floating floor slab, CLT



Structure
- floating floor slab [40 mm]
- impact sound isolation [30 mm]
- CLT [140 mm]**
- insulation [180 mm; rock wool]
- battens + air gap [50 mm]
- fiber cement board [8 mm]

Charring 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.

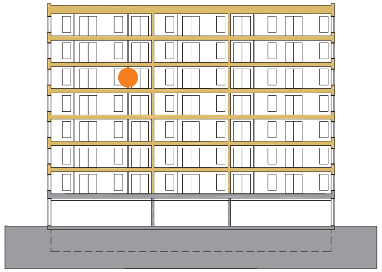
Type	Insulation	Surface material	Thickness	Fire resistance	U [W/m²K]	Surface reaction to fire		Charring		R_w (C; C_{tr}) [dB]
						Inner	Outer	R60	R90	
A.0	180 mm	gypsum boards [2 × 15 mm]	463 mm	REI 60	0.13	–	–	16 mm	36 mm	–

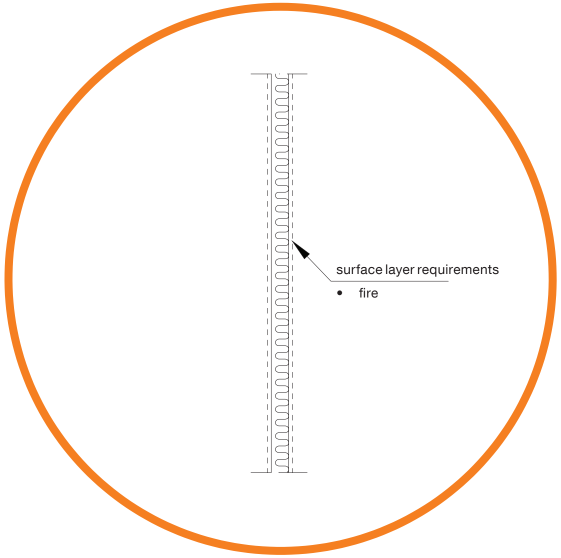
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

VS 1

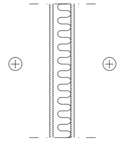
Non-load-bearing partition wall, inside apartment





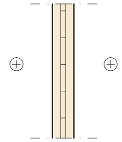
Variables

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.

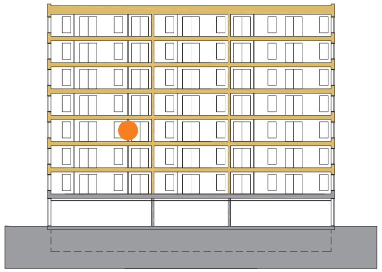
Type	Insulation	Surface material	Thickness	Fire resistance	Surface reaction to fire	R_w (C; C_{tr}) [dB]
A.0	50 mm	gypsum board [13 mm] / tiles	104 mm	EI 30	A2-s1,d0/–	46 (–1; –5)
A.1	50 mm	wood based panel / tiles	106 mm	–	D-s2, d2/–	46 (–1; –5)
B.0	–	visible CLT / tiles	105 mm	EI 60	D-s2, d0/–	37 (–1; –3)

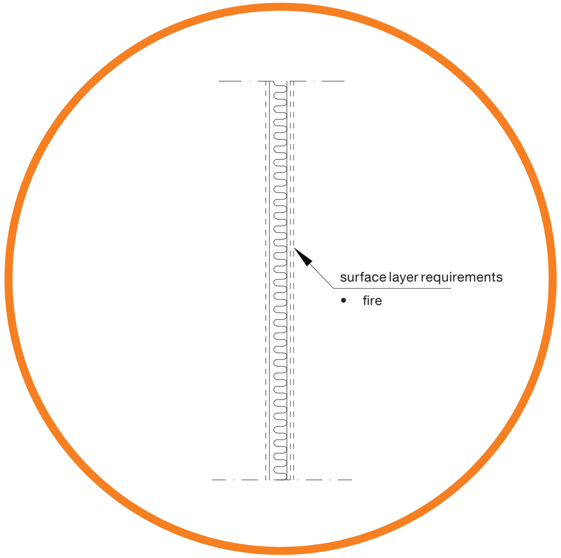
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

VS 2

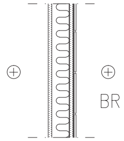
Non-load-bearing partition wall, inside apartment, bathroom





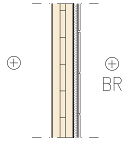
Variables

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.

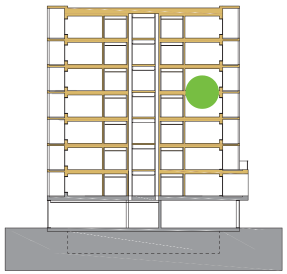
Type	Insulation	Surface material	Thickness	Fire resistance	Surface reaction to fire	R_w (C; C_{tr}) [dB]
A.0	50 mm	gypsum board [13 mm]	92 mm	EI 30	A2-s1,d0	40 (–2; –8)
A.1	50 mm	wooden panel	96 mm	–	D-s2, d0	40 (–2; –8)
B.0	–	visible CLT	80 mm	EI 60	D-s2, d0	32 (–1; –3)

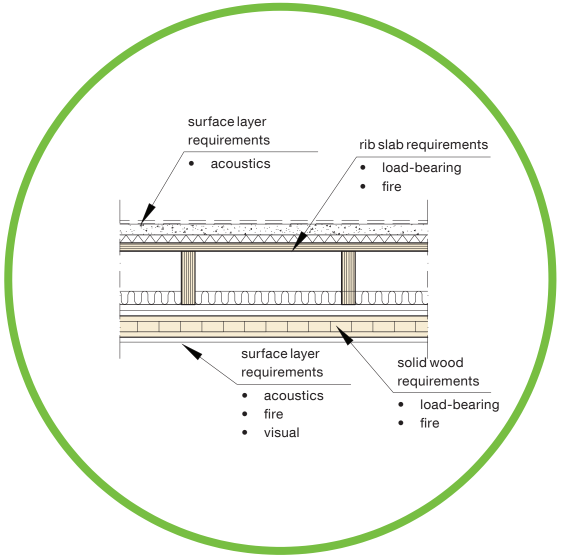
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

E-VP 12

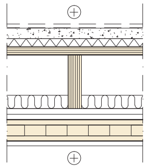
Intermediate floor, apartment





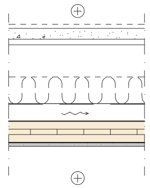
Variables

A. Floating floor slab, rib slab, CLT



Structure
- floating floor slab [40 mm]
- impact sound isolation [30 mm]
- LVL rib slab + insulation [50 mm]
- plank or board
- air gap
- CLT [80 mm]**
- gypsum board [18 mm]

B. Floor slab, timber joists, CLT, suspended ceiling



Structure
- floor slab
- chipboard
- timber joists + insulation [100 mm]
- air gap
- CLT [80 mm]**
- gypsum board [15 mm]

Charring 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	Fire resistance	Surface reaction to fire		R_w (C; C_{tr}) [dB]	$L_{n,w}$ (C_I) [dB]
					Floor	Ceiling		
A.0	50 mm	floor slab [40 mm] / gypsum board [18 mm]	456 mm	REI 60	–	A2-s1,d0	58 (–1; –4)	78 (–11)
B.0	50 mm	floor slab [40 mm] / gypsum board [15 mm]	457 mm	–	–	A2-s1,d0	62 (–1; –4)	78 (–9)

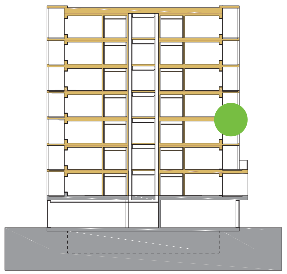
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

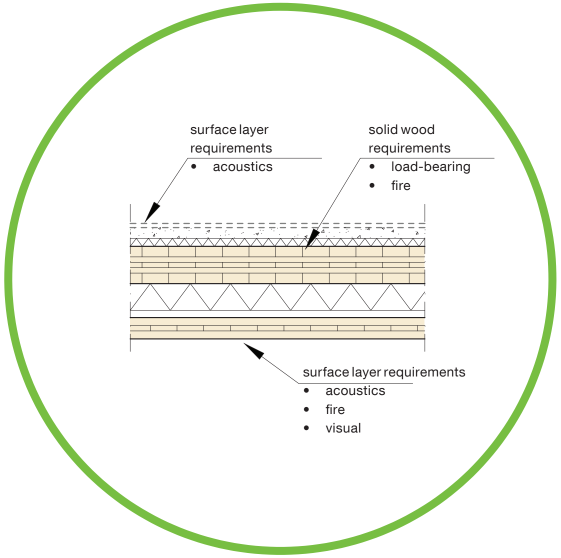
* variable
** according to structural calculations

rethink.
storaenso

E-VP 42

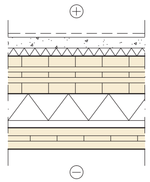
CLT slab intermediate floor,
recessed balcony, apartment





Variables

A. Floating floor slab, visual CLT



Structure

- floating floor slab [40 mm]
- impact sound isolation [30 mm]
- CLT [140 mm]**
- insulation [100 mm]
- air gap
- CLT [80 mm]**

Charring 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.

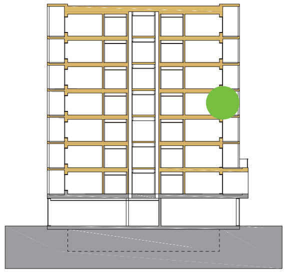
Type	Insulation	Surface material	Thickness	Fire resistance	U [W/m²K]	Surface reaction to fire		Charring		R_w (C; C_{tr}) [dB]	$L_{n,w}$ (C_l) [dB]
						Floor	Ceiling	R60	R90		
A.0	100 mm	floor slab [40 mm] / CLT	432 mm	REI 60	0.17		A2-s1,d0	25 mm	45 mm	61 (–1: –5)	75 (–10)

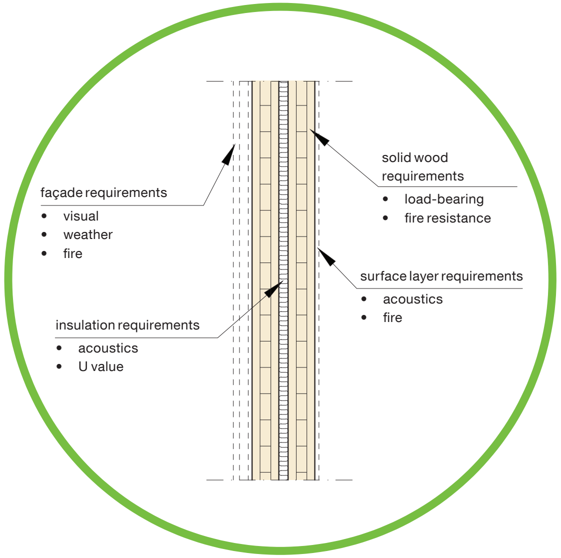
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

* variable
** according to structural calculations

E-VSK 12

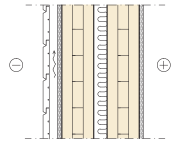
Load-bearing partition wall,
recessed balcony, apartment





Variables

A. Wood cladding, double CLT, gypsum boards



Structure
- cladding
- air gap [32 mm]
- gypsum board [15 mm]
- CLT [120 mm]**
- air gap [50 mm] + insulation [30 mm]
- CLT [120 mm]**
- gypsum board [15 mm]

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

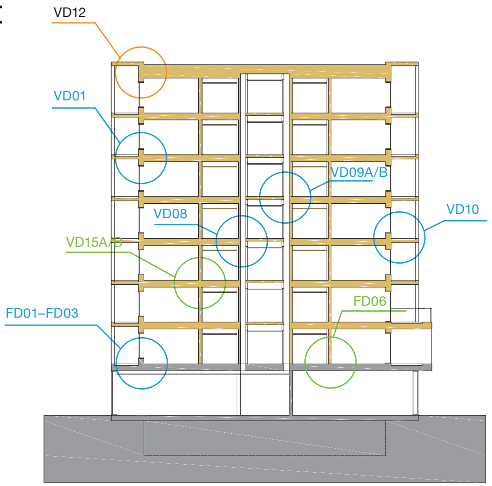
Type	Insulation	Surface material	Thickness (CLT 120 mm)	Minimum CLT cross-section				U [W/m²K]	Surface reaction to fire		R_w (C; C_{tr}) [dB]
				R60		R90					
				4 floors	7 floors	4 floors	7 floors		Inner	Outer	
A.0	30 mm	gypsum board [15 mm]	375 mm	120 C3s	120 C3s	140 C5s	140 C5s	0.29	A2-s1,d0	D-s2, d0	52 (–4; –9)

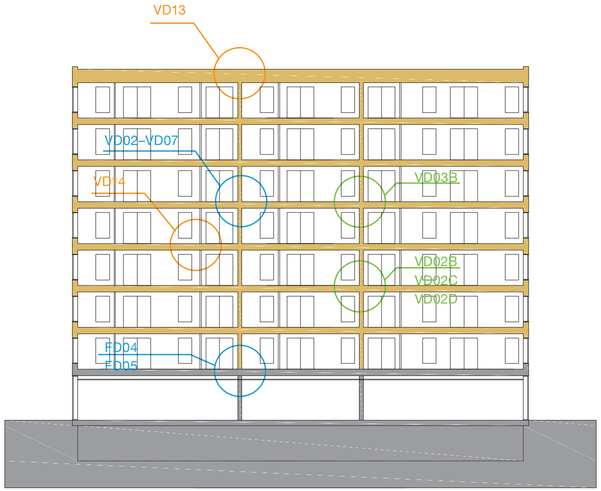
Note that all final solutions need to be reviewed and approved by responsible designer. See 1.3 (Disclaimer, page 5).

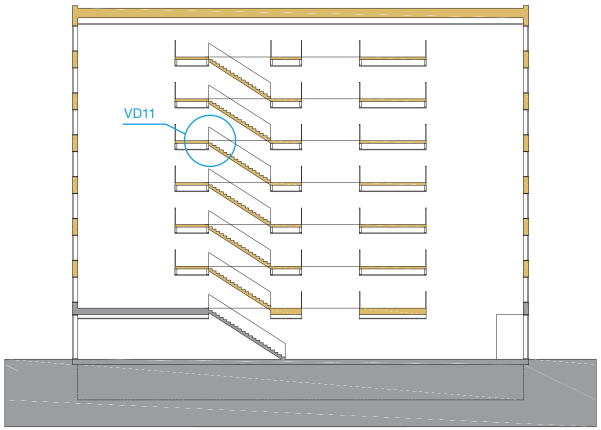
* variable
** according to structural calculations

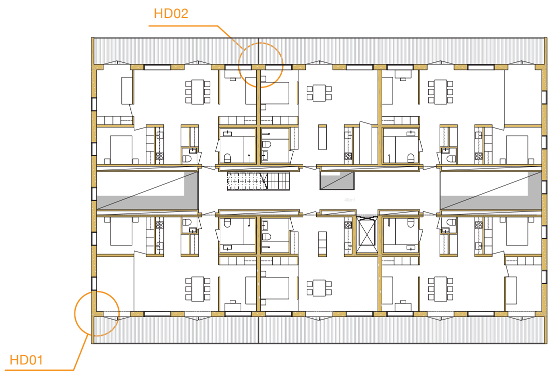
5.2 Structural details

Orientation chart







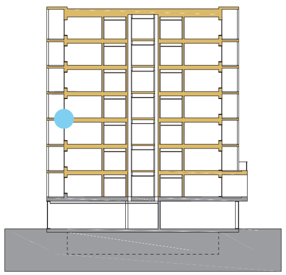


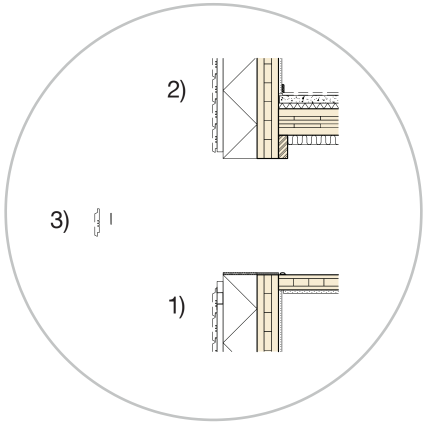
List of Drawings

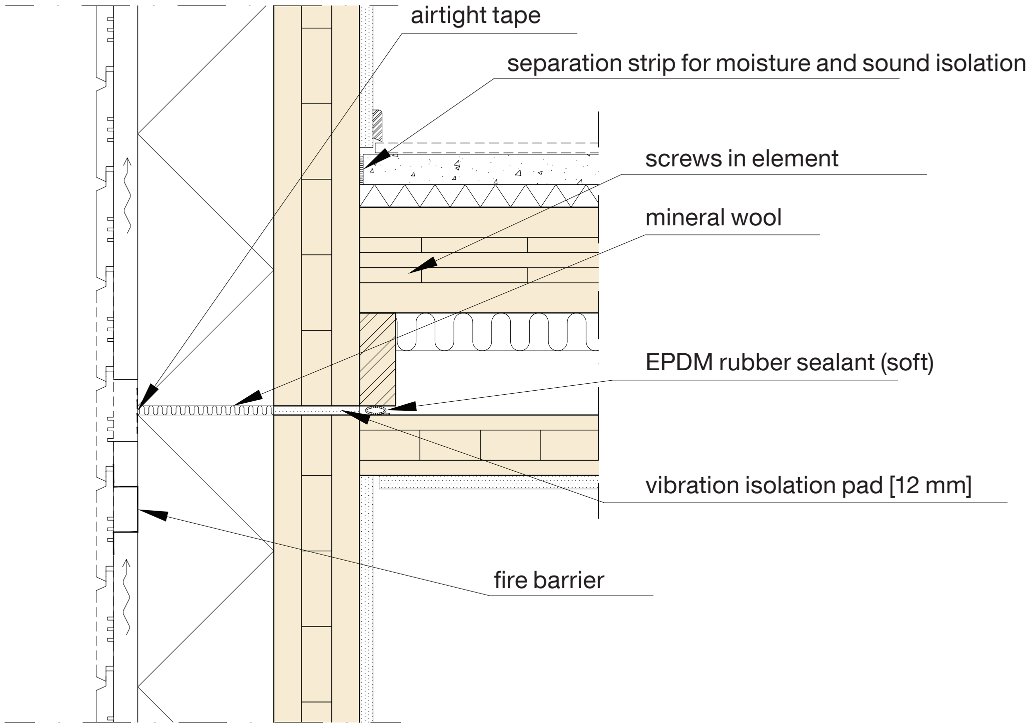
Detail name	No.		Description	Note
VD	1		Intermediate floor to load-bearing external wall, apartment	
VD	2	A	Intermediate floor to partition wall, apartment	
		B	Intermediate floor to partition wall, apartment, beam and post	Extension
		C	Intermediate floor to partition wall, apartment, beam floor	Extension
		D	Intermediate floor to partition wall, apartment, rib slab floor	Extension
VD	3	A	Intermediate floor to load-bearing partition wall, bathroom	
		B	Intermediate floor to load-bearing partition wall, sanitary box element	Extension
VD	4	A	Connection for uplift, continuous tension bar, double shear walls	
		B	Connection for uplift, continuous tension bar, one shear wall	
VD	5	A	Connection for shear, wood to wood connection	
		B	Connection for shear, steel connection	
VD	6		Connection for shear, between intermediate floors	
VD	7		Connection for tension and compression between intermediate floors	
VD	8		Intermediate floor to partition wall, corridor	
VD	9	A	Intermediate floor to partition wall, corridor	
		B	Intermediate floor to partition wall, corridor	
VD	10		Balcony floor to load-bearing external wall	
VD	11		Stairs to intermediate floor, corridor	
VD	12		Roof to external wall	
VD	13		Roof to load-bearing partition wall	
VD	14		Intermediate floor to non-load-bearing partition wall, apartment	
VD	15	A	Two modules forming one room	Extension
		B	Two modules forming one room	Extension
VD	16	A	Intermediate floor to concrete wall, apartment	Extension
		B	Intermediate floor to concrete wall, apartment	Extension
VD	17		Intermediate floor to external wall, cantilever apartment	Extension
FD	1		External wall to ground floor, apartment	
FD	2		External wall to ground floor, uplift tie	
FD	3		External wall to ground floor, shear transfer	
FD	4		Partition wall to ground floor, uplift connection	
FD	5		Partition wall to ground floor, shear connection	
FD	6		Partition wall to ground floor, inside apartment	Extension
HD	1		Salient corner	
HD	2		T-connection	
HD	3		Re-entrant corner	

VD 1

Intermediate floor to load-bearing external wall, apartment



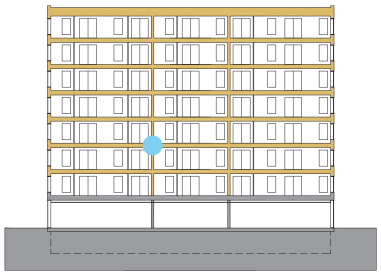


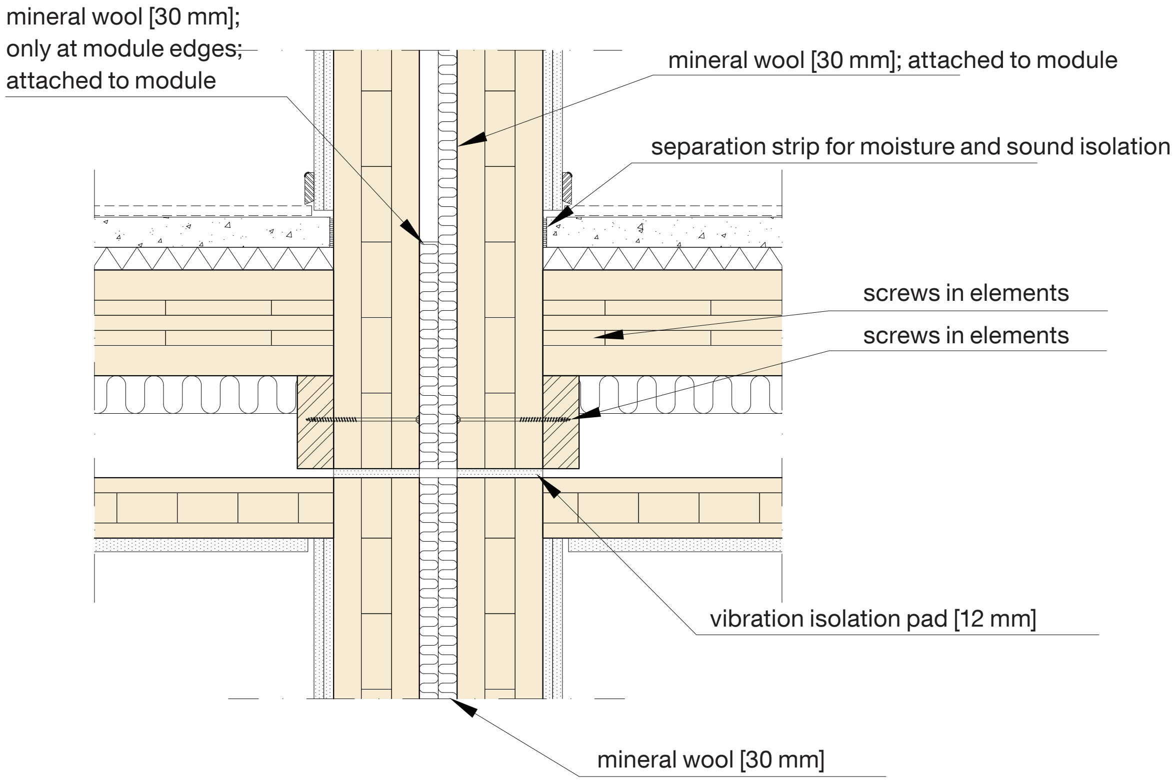


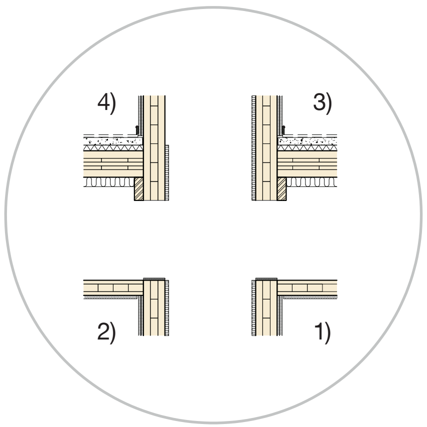
Exact amount, size and spacing of fastener according to structural engineer.

VD 2 A

Intermediate floor to partition wall, apartment



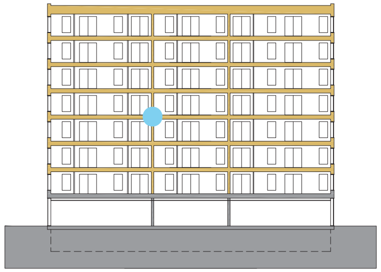


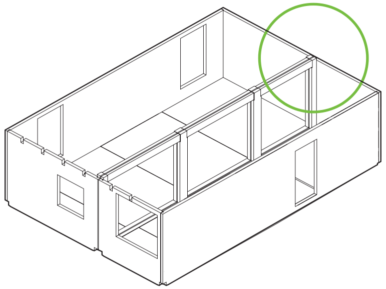


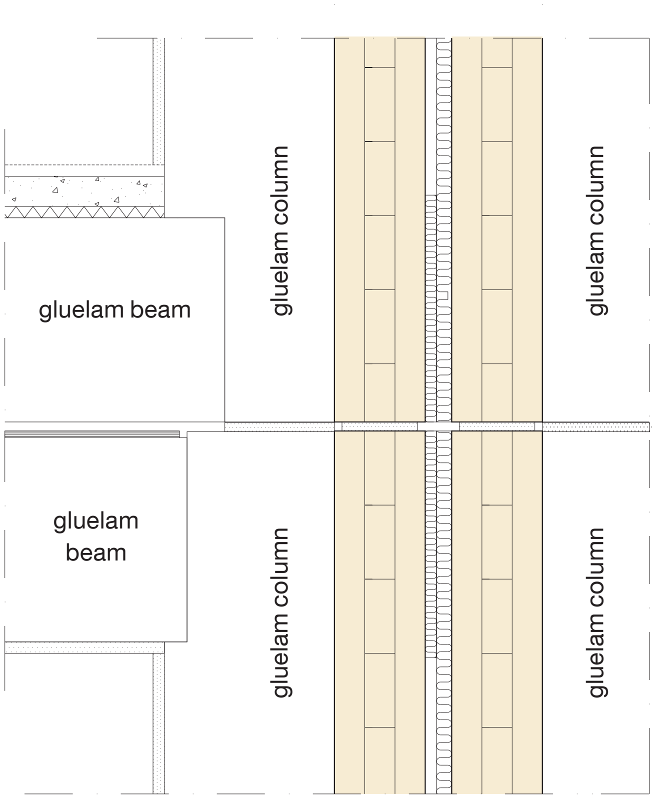
Exact amount, size and spacing of fastener according to structural engineer.

VD 2 B

Intermediate floor to partition wall, apartment, beam and post



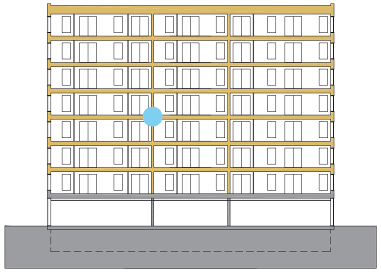


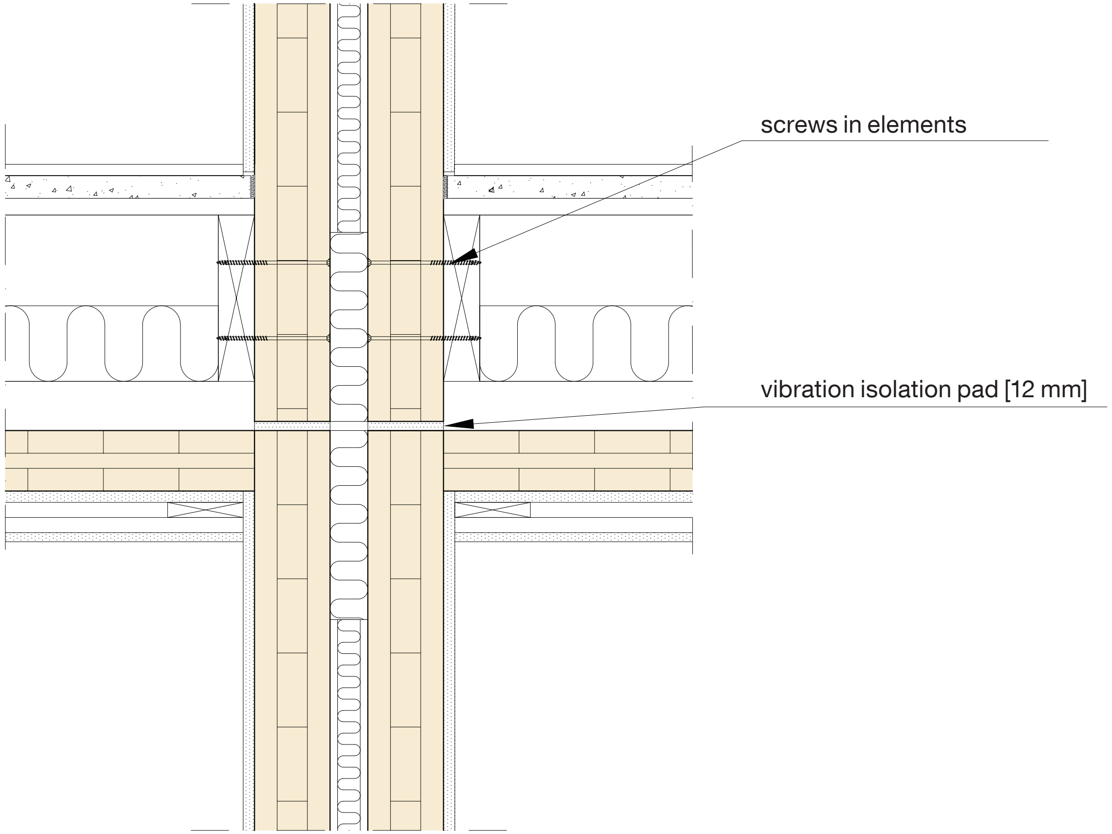


Exact amount, size and spacing of fastener according to structural engineer.

VD 2 C

Intermediate floor to partition wall, apartment, beam floor

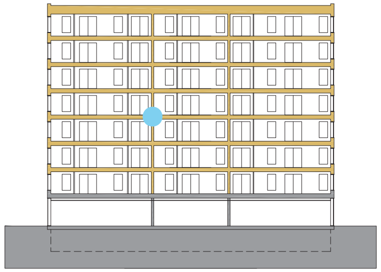


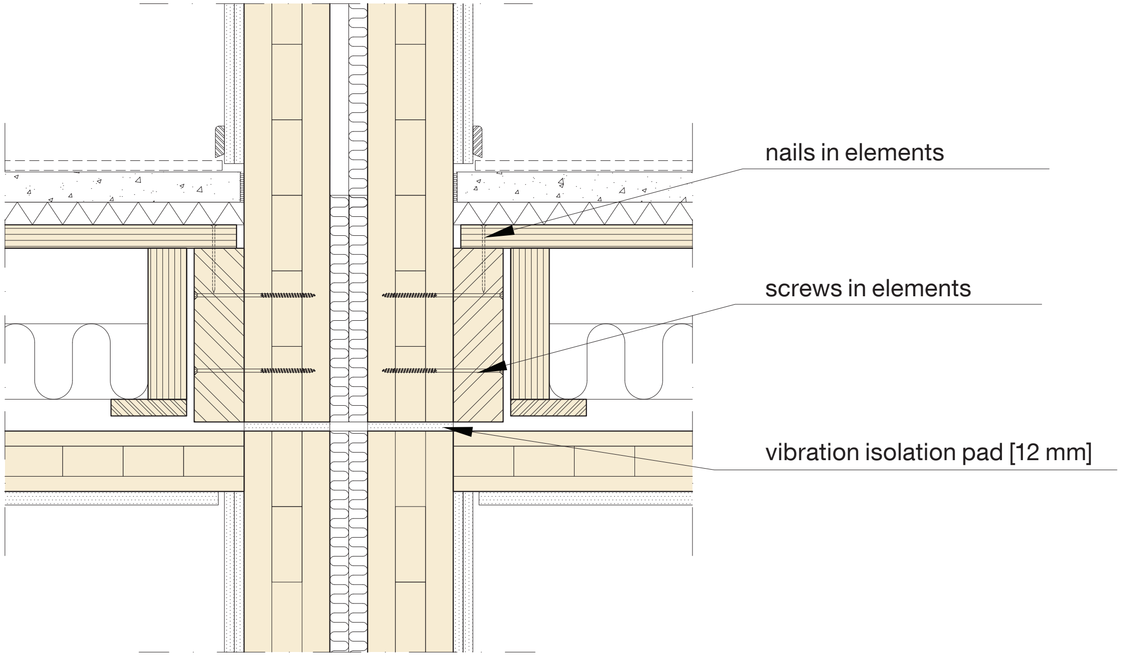


Exact amount, size and spacing of fastener according to structural engineer.

VD 2 D

Intermediate floor to partition wall, apartment, rib slab floor

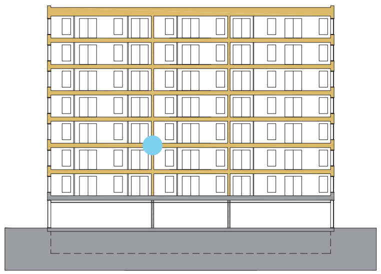


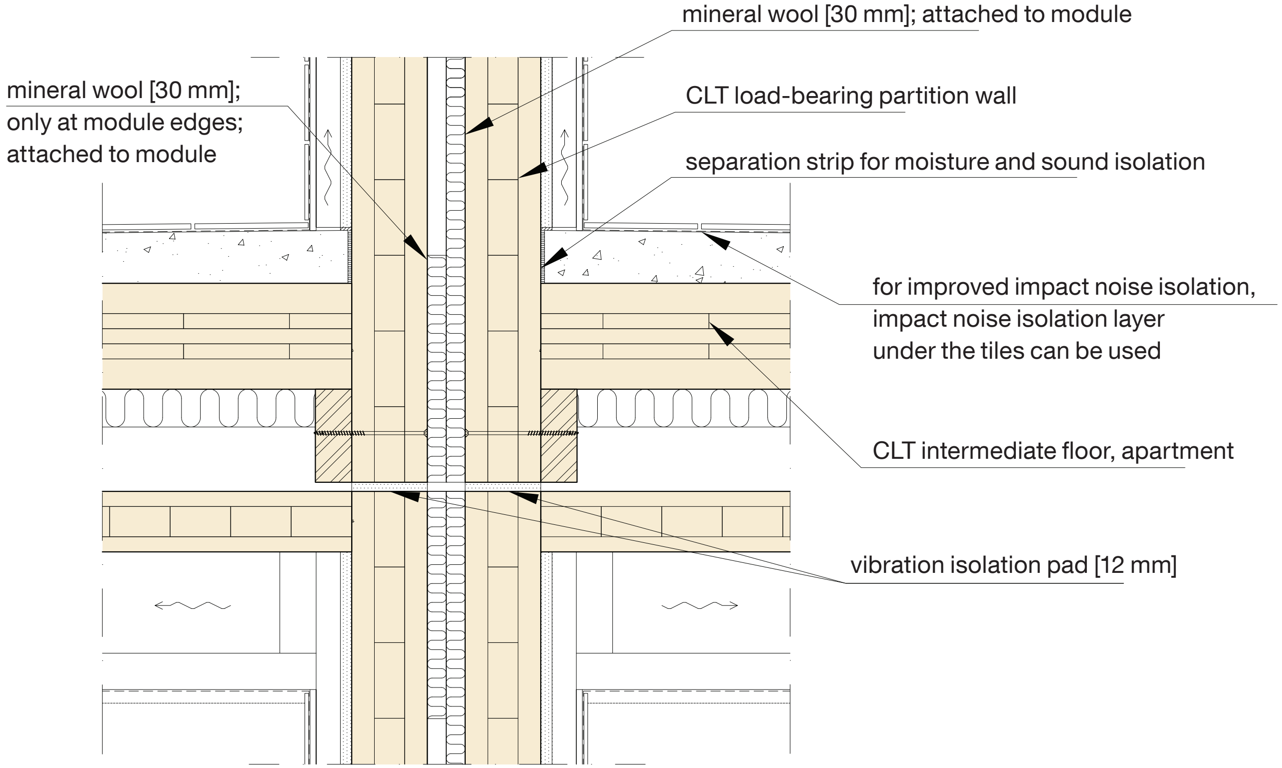


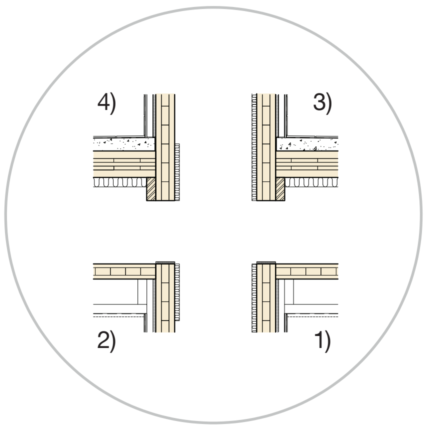
Exact amount, size and spacing of fastener according to structural engineer.

VD 3 A

Intermediate floor to load-bearing partition wall, bathroom







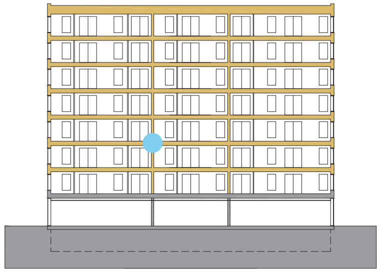
Note! Compensation air and air flow in horizontal direction need to be arranged.

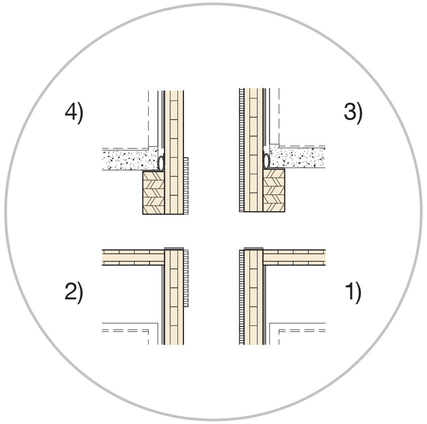
Exact amount, size and spacing of fastener according to structural engineer.

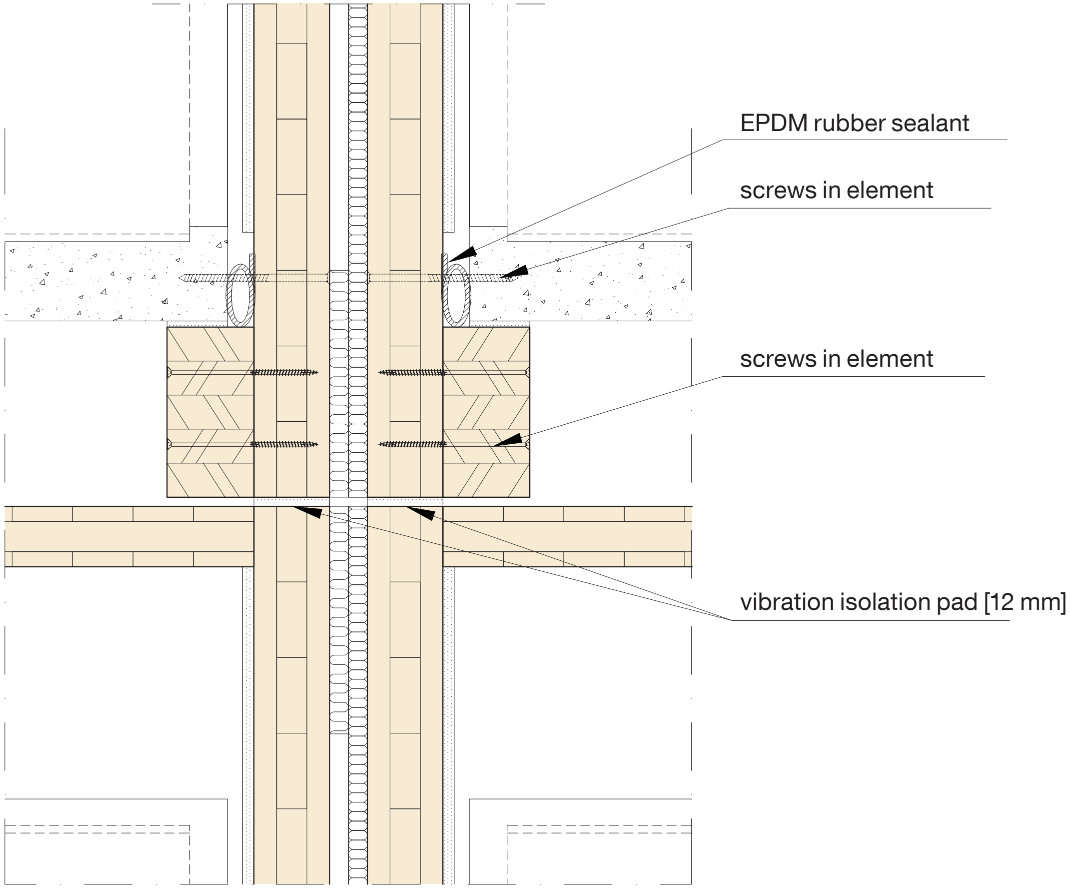
storaenso rethink.

VD 3 B

Intermediate floor to load-bearing partition wall, sanitary box element



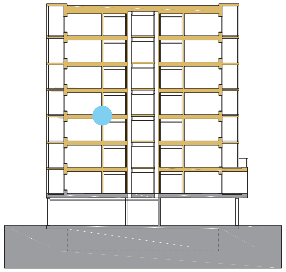


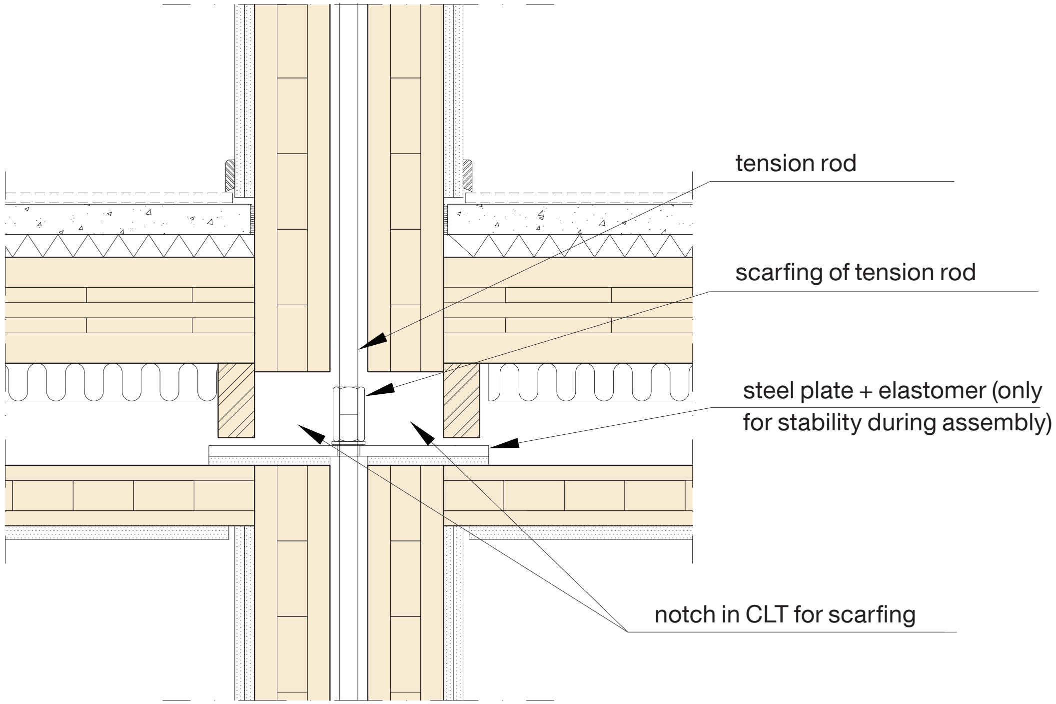


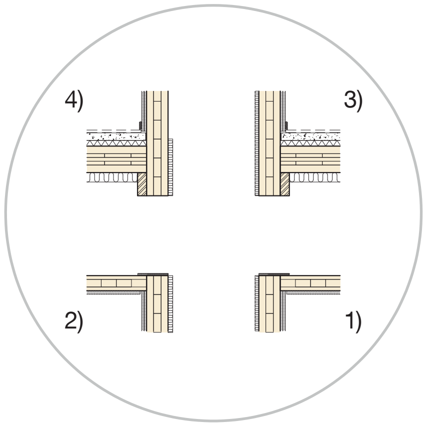
Exact amount, size and spacing of fastener according to structural engineer.

VD 4 A

Connection for uplift, continuous tension bar, double shear walls



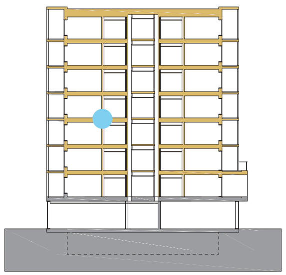


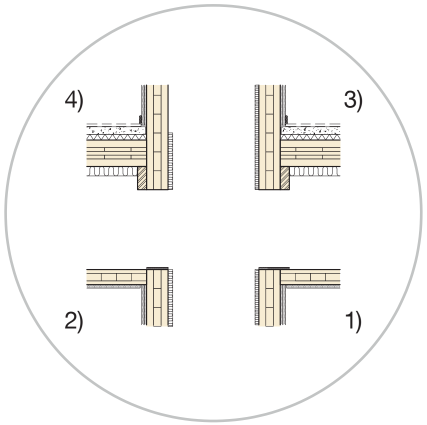


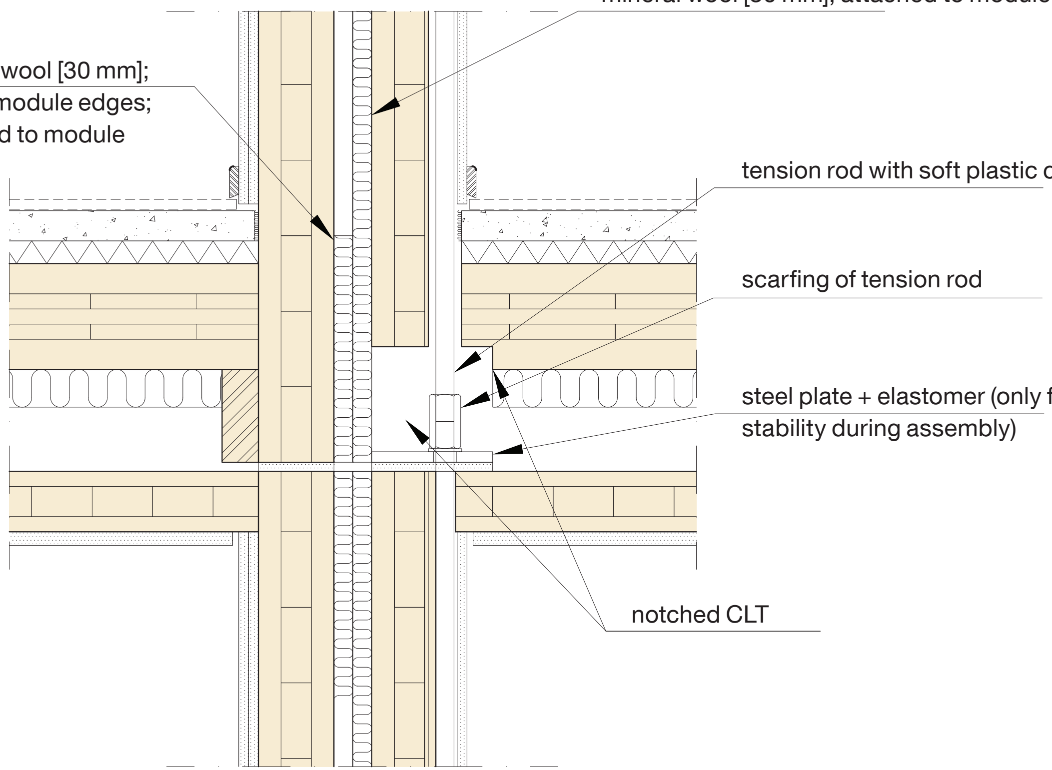
Exact amount, size and spacing of fastener according to structural engineer.

VD 4 B

Connection for uplift, continuous tension bar, one shear wall



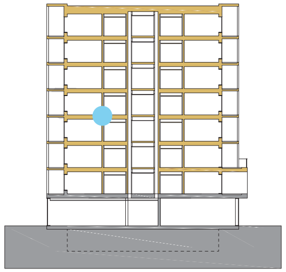


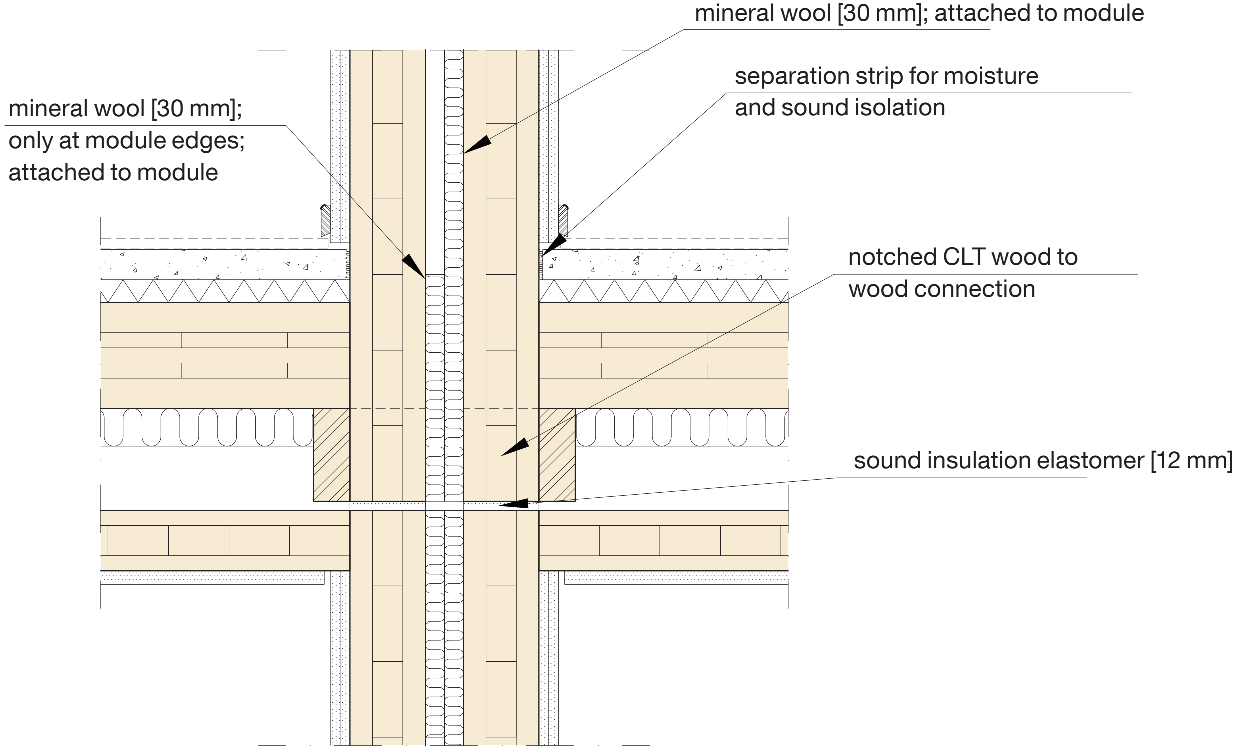


Exact amount, size and spacing of fastener according to structural engineer.

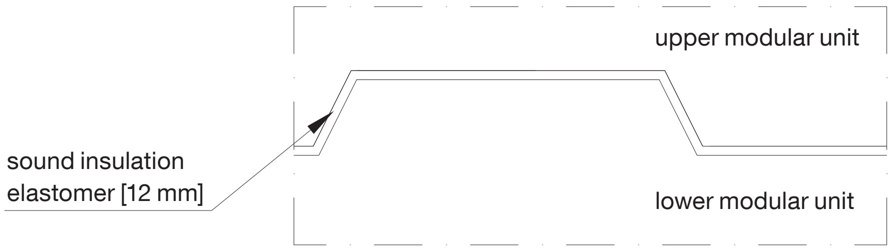
VD 5 A

Connection for shear, wood to wood connection





Shear connection of overlapping modules, number and size of connections according to structural engineer

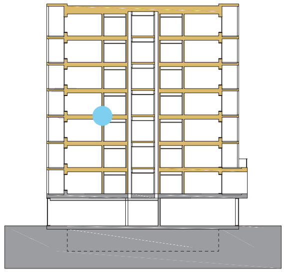


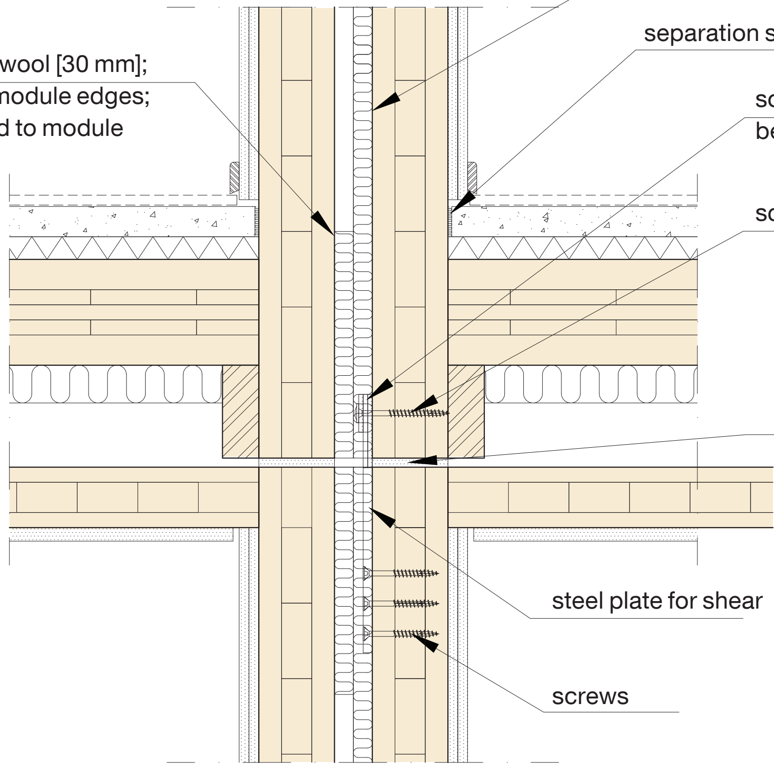
Exact amount, size and spacing of fastener according to structural engineer.

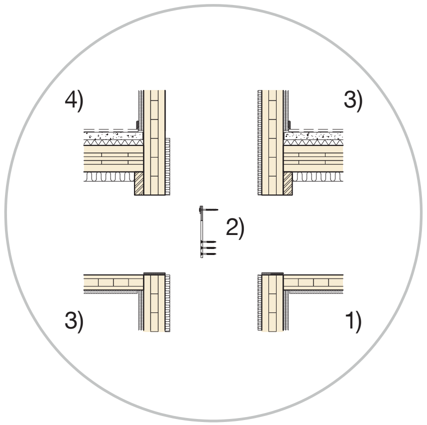
rethink.
storaenso

VD 5 B

Connection for shear, steel connection



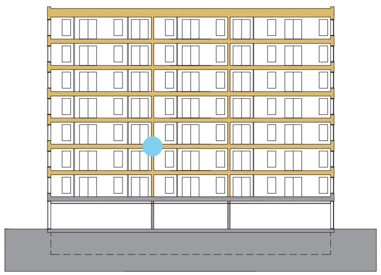


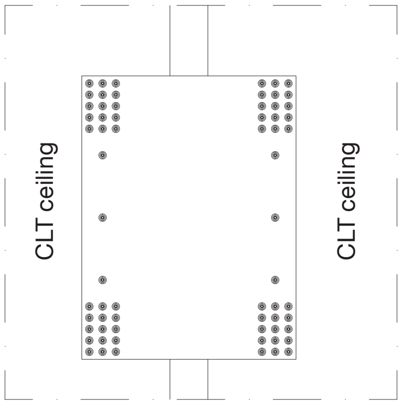


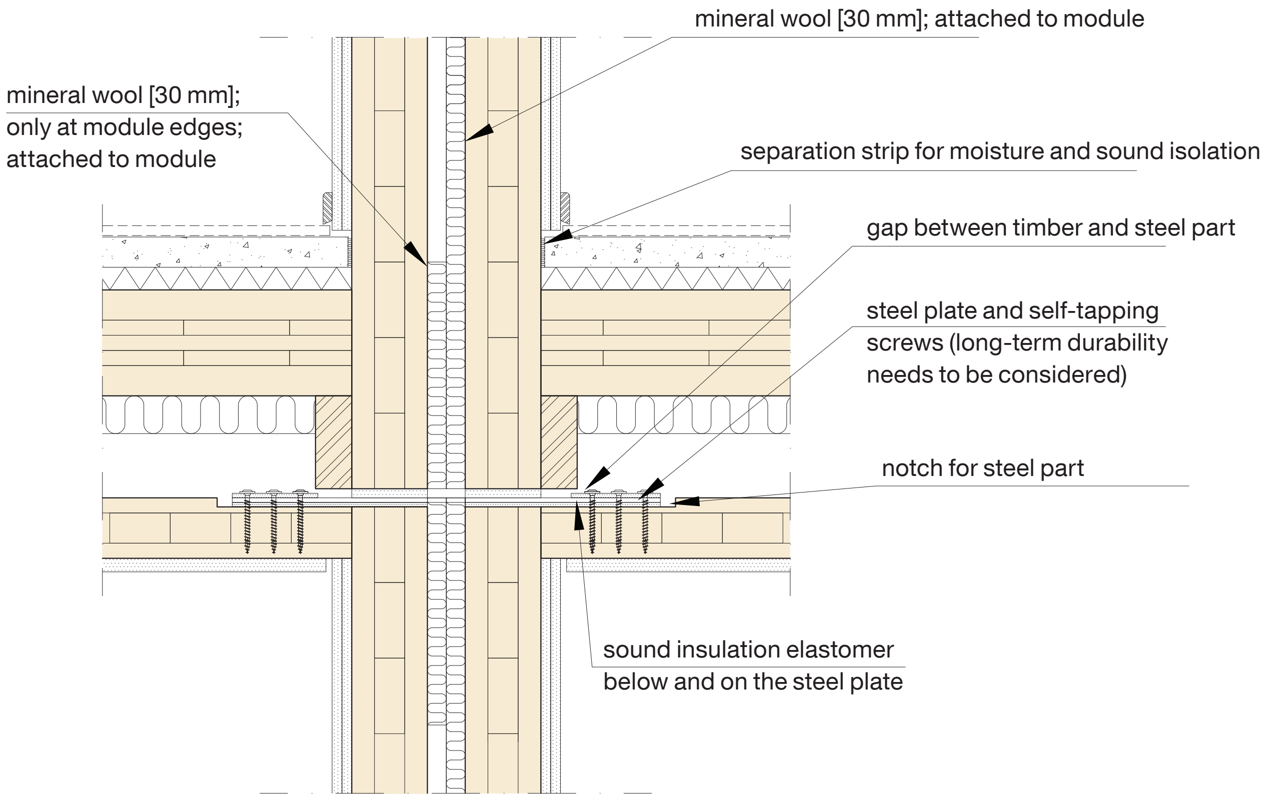
Exact amount, size and spacing of fastener according to structural engineer.

VD 6

Connection for shear, between intermediate floors





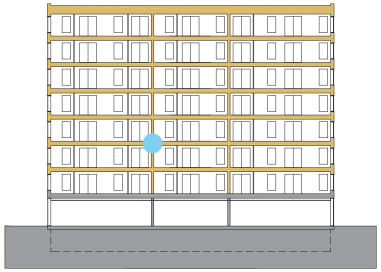


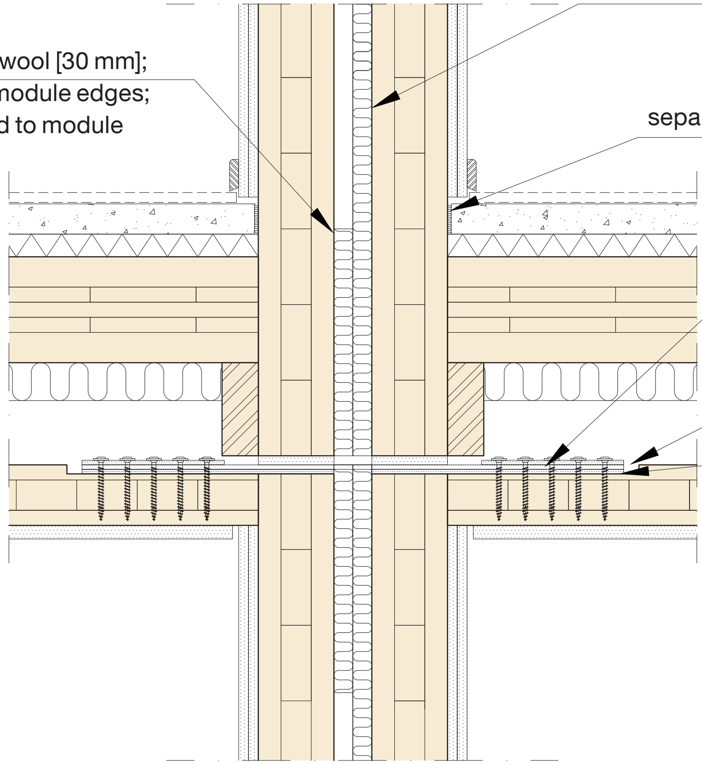
For improved sound isolation, avoid placing steel connections in living rooms or bedrooms.

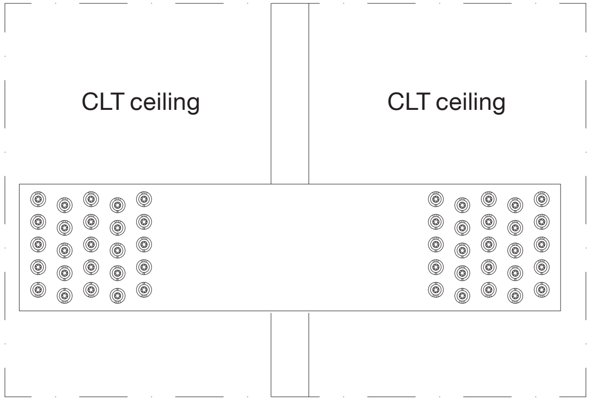
Exact amount, size and spacing of fastener according to structural engineer.

VD 7

Connection for tension and compression between intermediate floors







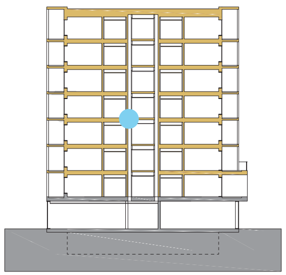
For improved sound isolation, compression/tension forces and shear forces are managed with different steel connections. It is not recommended to install multiple steel parts to same location for decreased sound isolation.

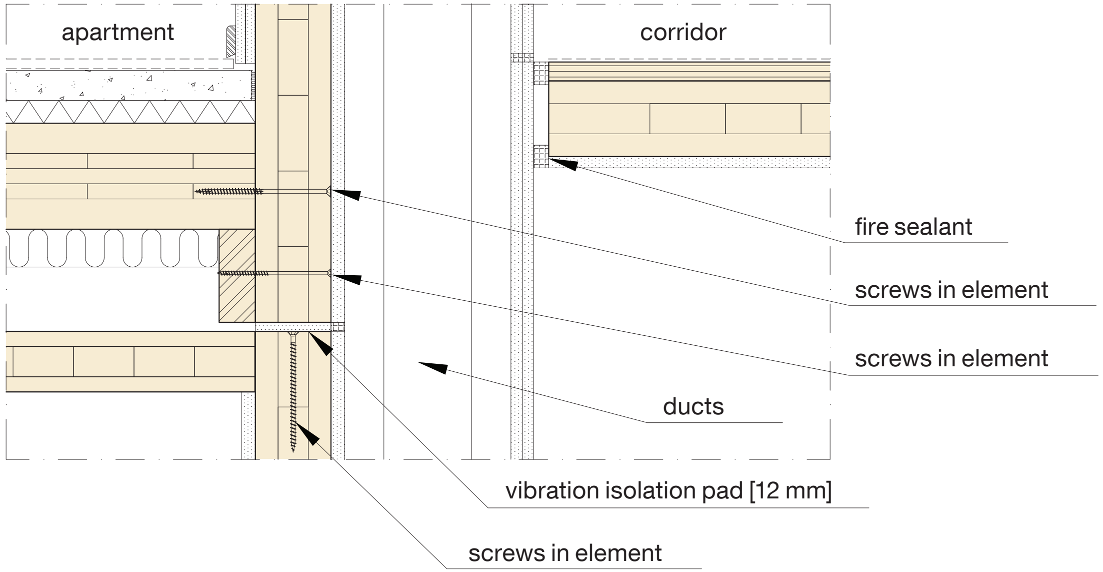
Exact amount, size and spacing of fastener according to structural engineer.

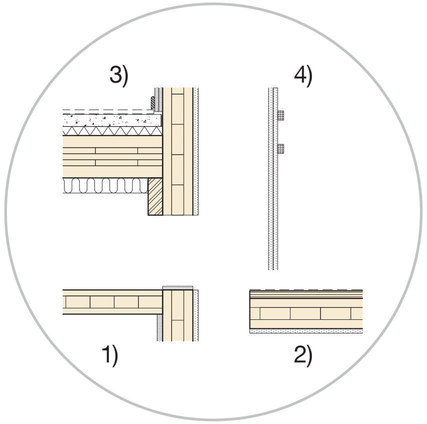
rethink.
storaenso

VD 8

Intermediate floor to partition wall, corridor





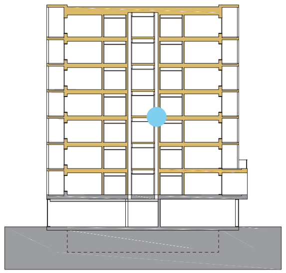


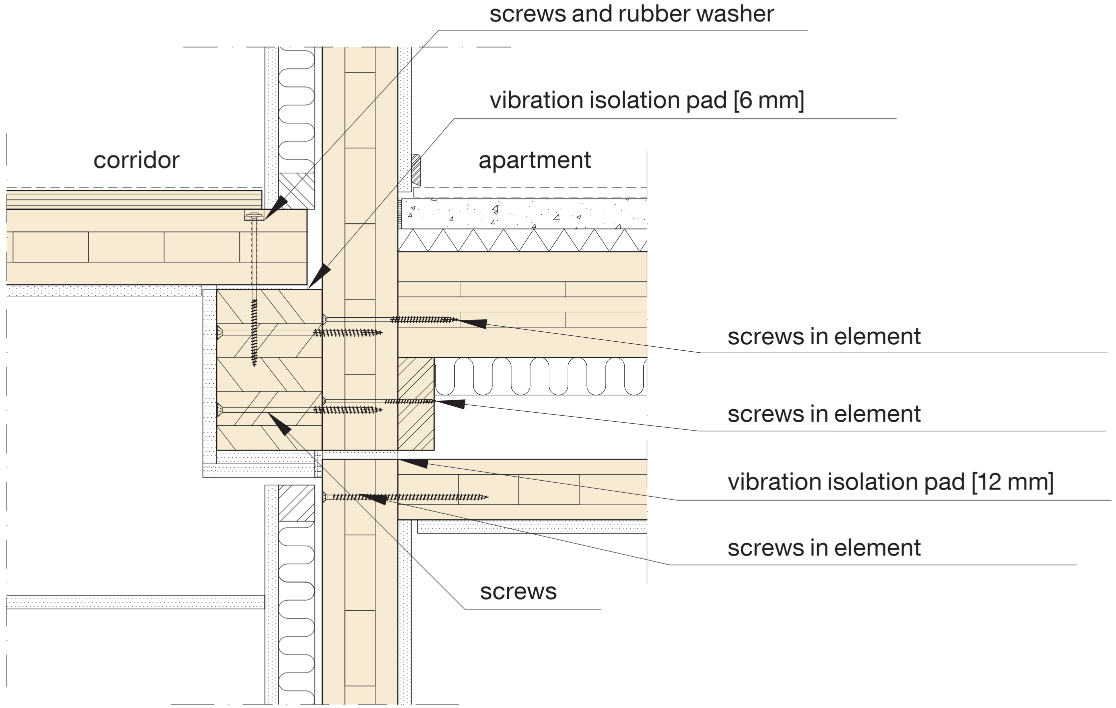
Service shaft and corridor structures are built on site.

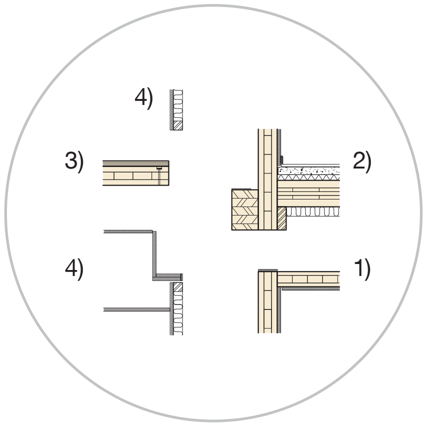
Exact amount, size and spacing of fastener according to structural engineer.

VD 9 A

Intermediate floor to partition wall, corridor





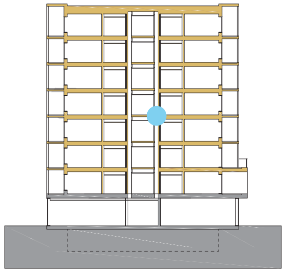


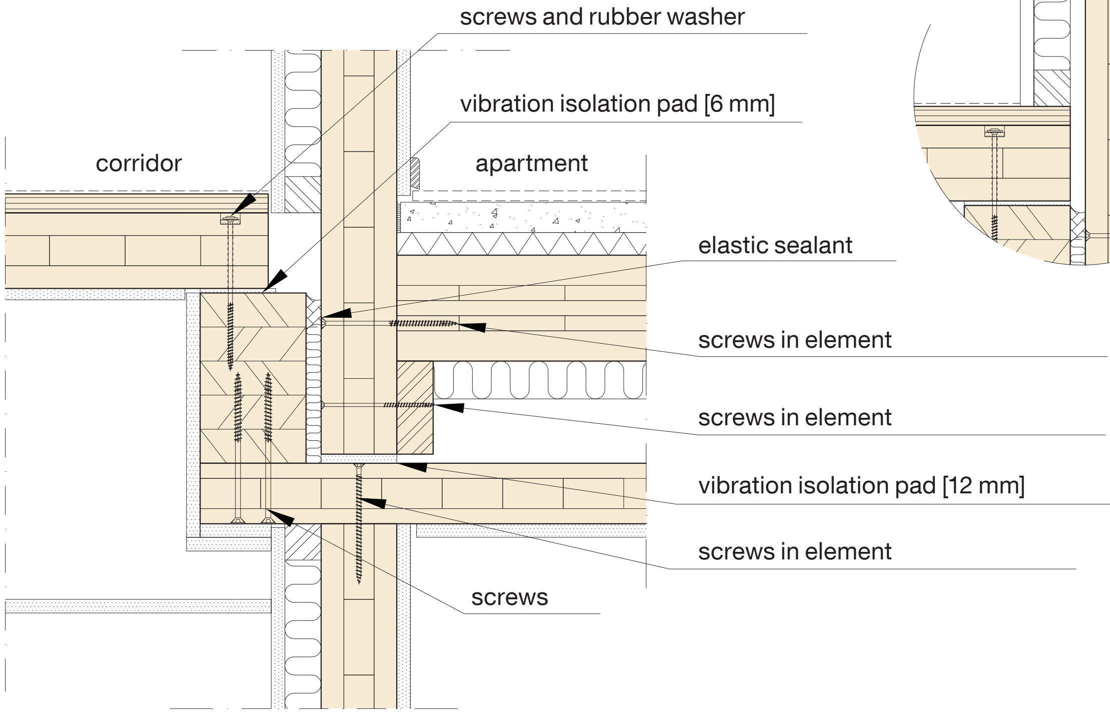
Corridor structures are built on site.

Exact amount, size and spacing of fastener according to structural engineer.

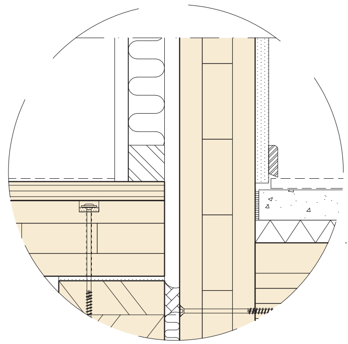
VD 9 B

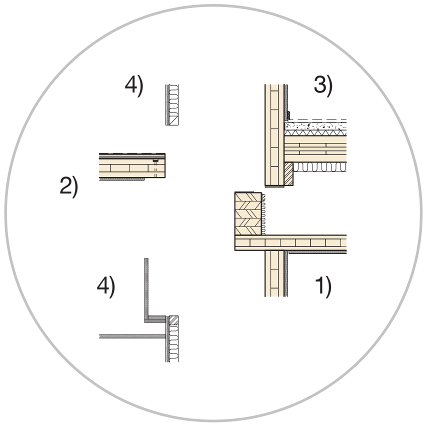
Intermediate floor to partition wall, corridor





Option B
Improved acoustic performance





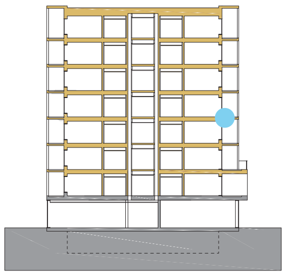
Corridor structures are built on site.

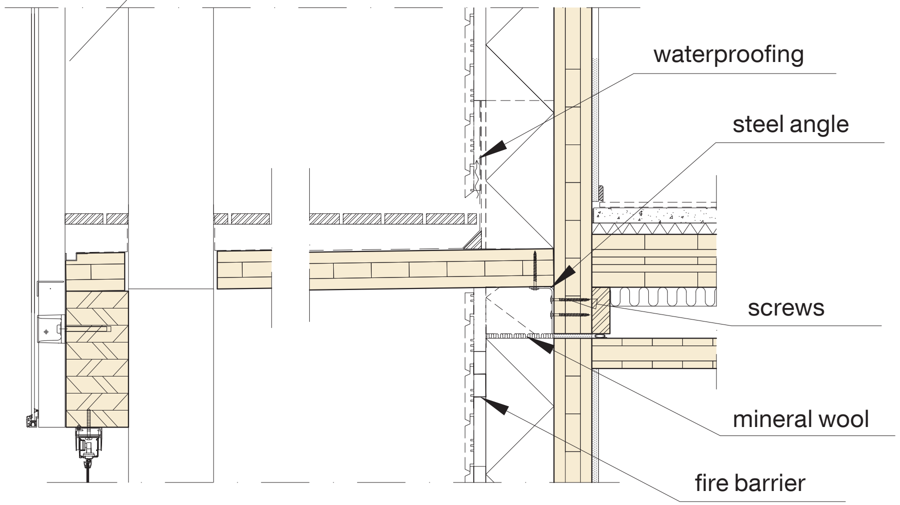
It is recommended to use impact sound isolation layer in corridor if the room below is living room or bedroom.

Exact amount, size and spacing of fastener according to structural engineer.

VD 10

Balcony floor to load-bearing external wall

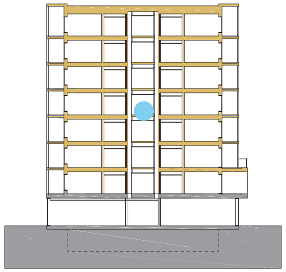


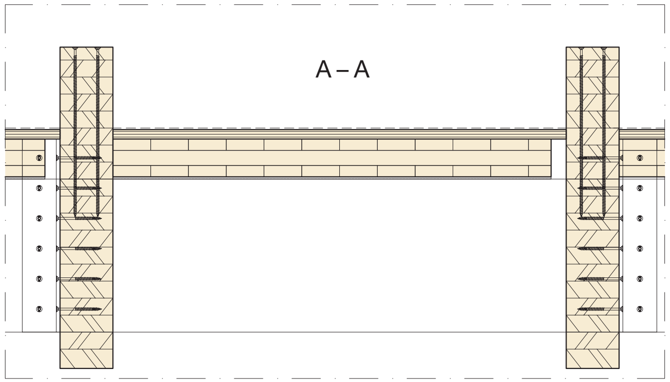


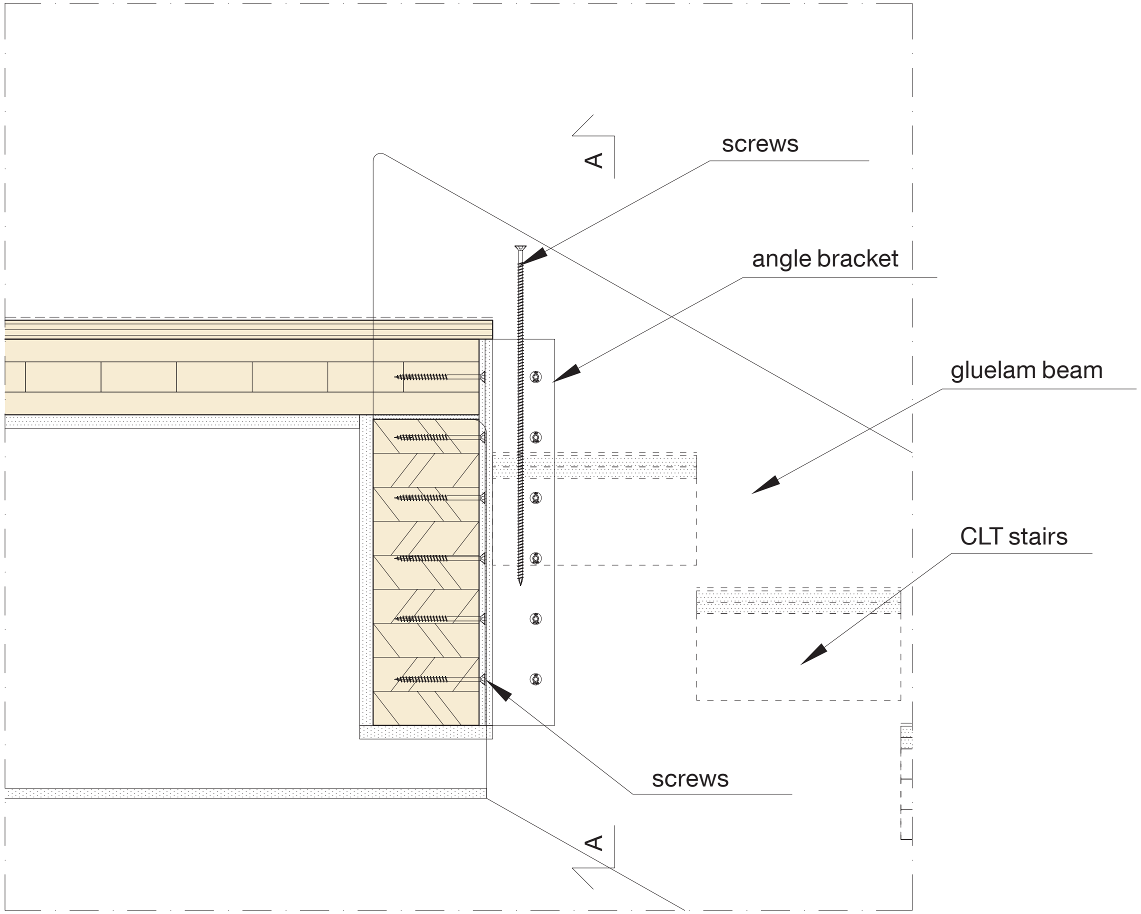
Exact amount, size and spacing of fastener according to structural engineer.

VD 11

Stairs to intermediate floor, corridor



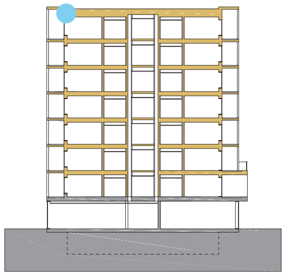


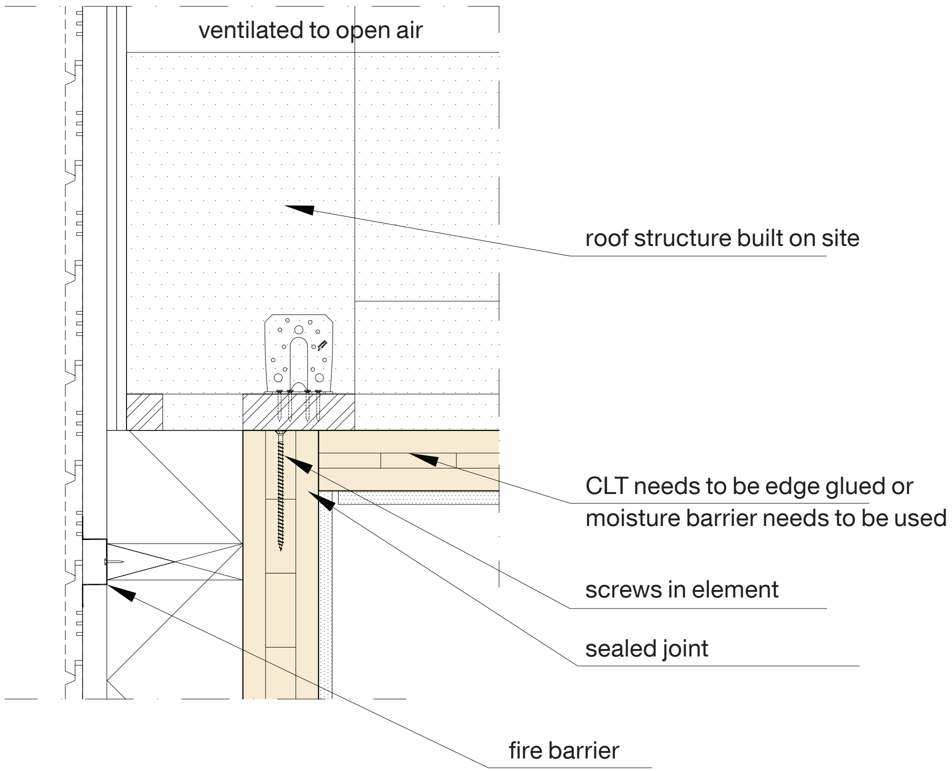


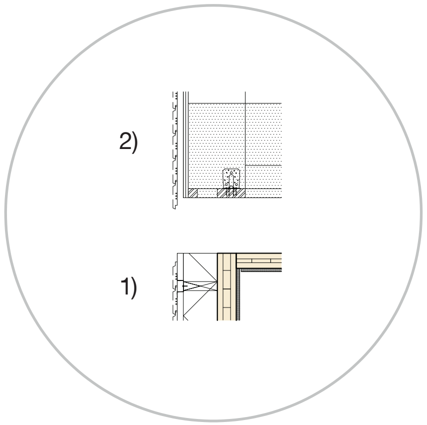
Exact amount, size and spacing of fastener according to structural engineer.

VD 12

Roof to external wall



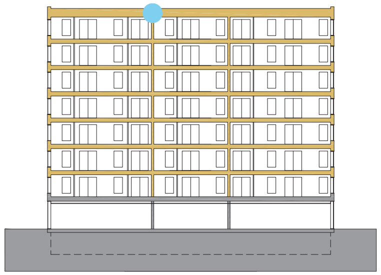


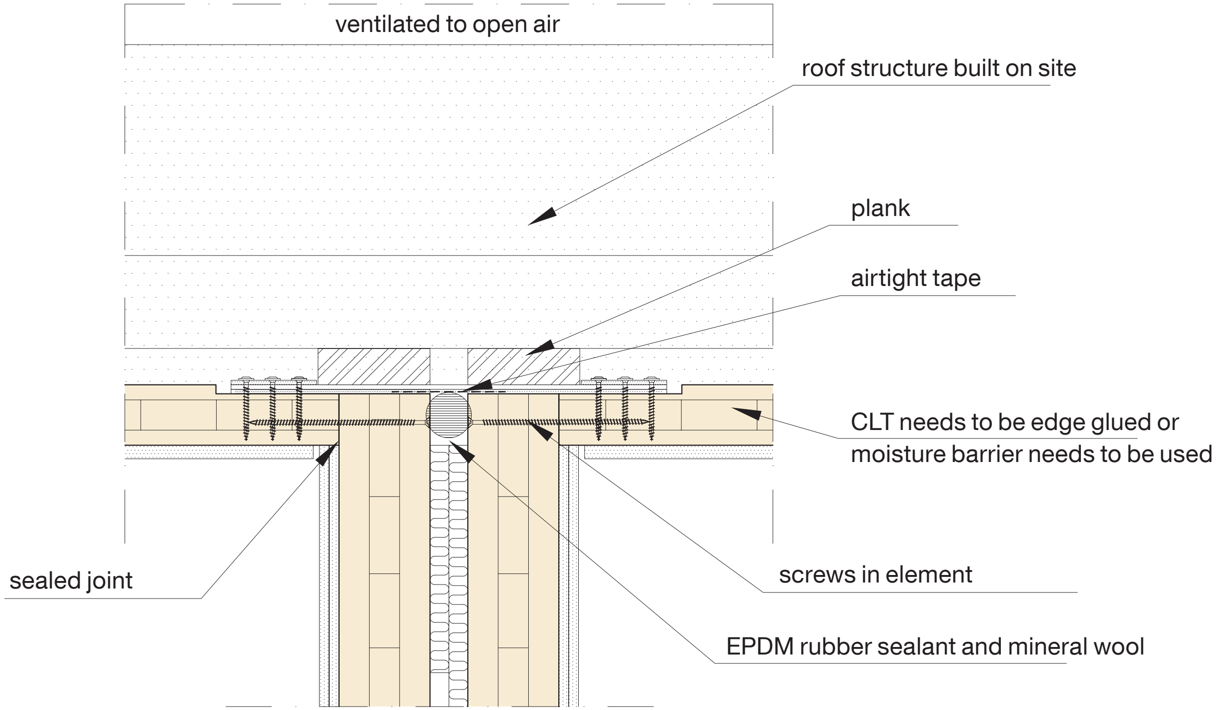


Exact amount, size and spacing of fastener according to structural engineer.

VD 13

Roof to load-bearing partition wall



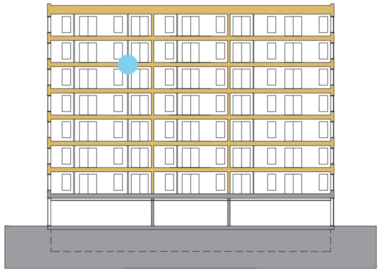


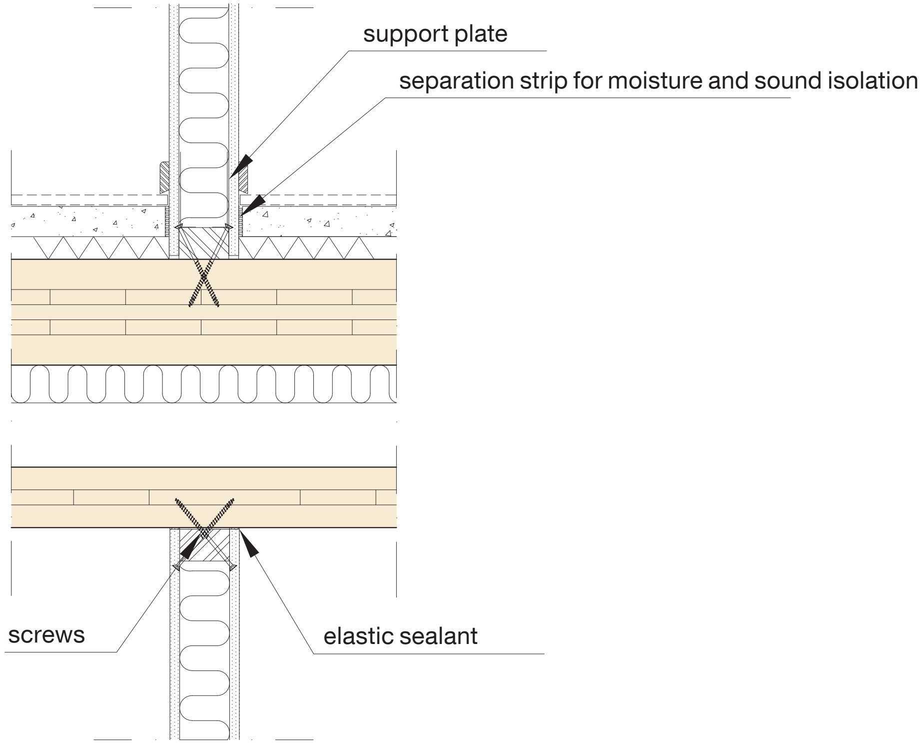
If roof truss connects modules that are part of different flats, vibration isolation pad should be used under the truss.

Exact amount, size and spacing of fastener according to structural engineer.

VD 14

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

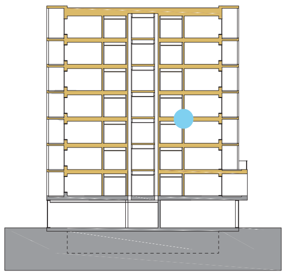


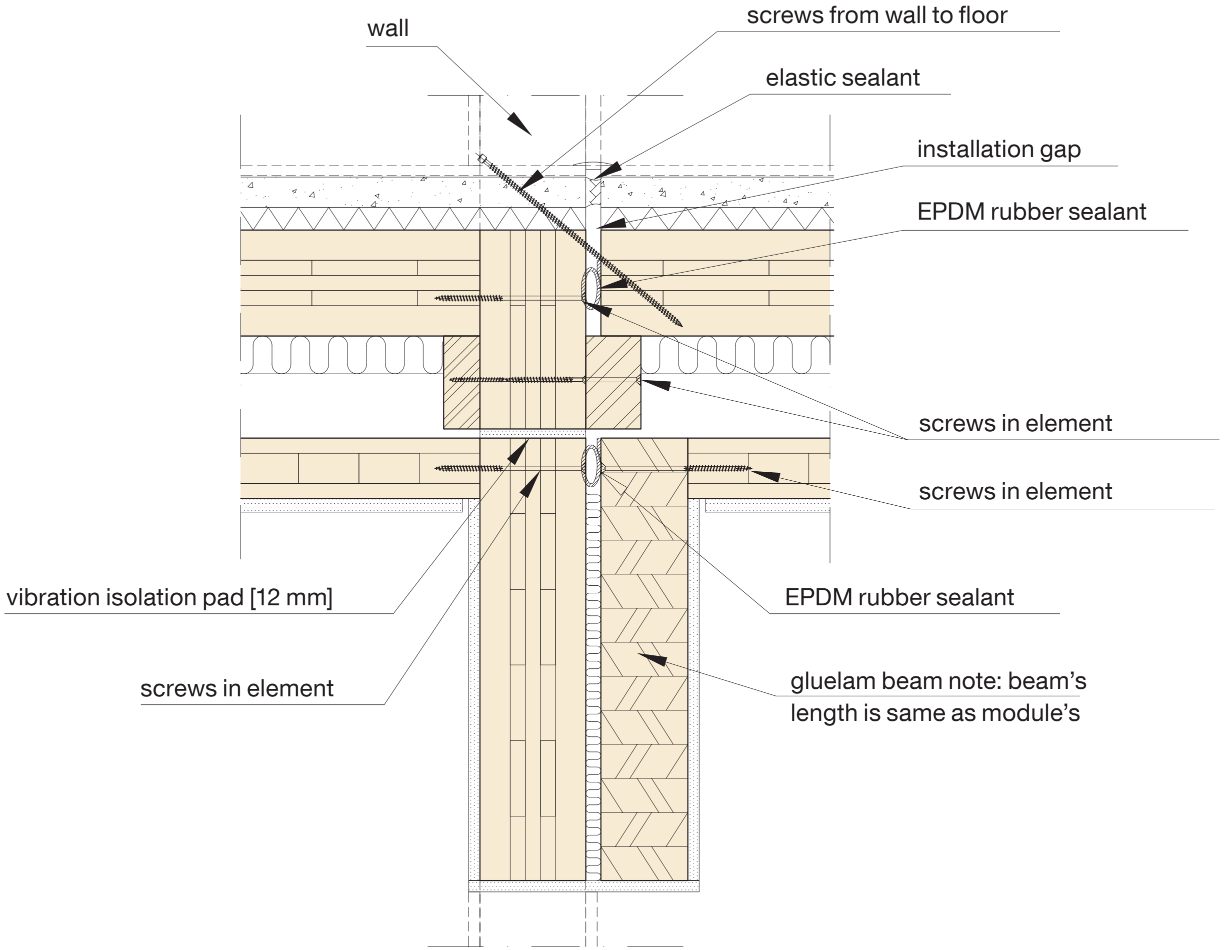


Exact amount, size and spacing of fastener according to structural engineer.

VD 15 A

Two modules forming one room

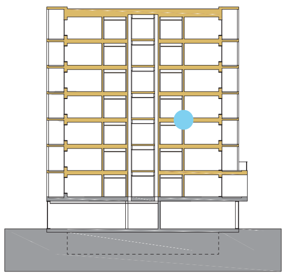


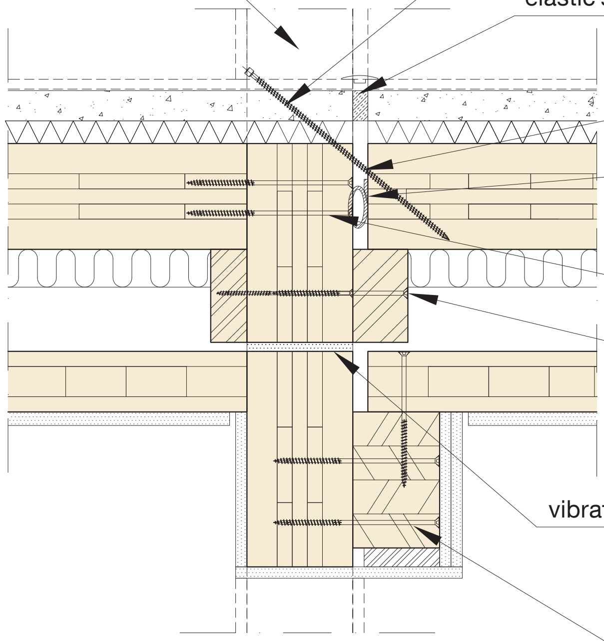


Exact amount, size and spacing of fastener according to structural engineer.

VD 15 B

Two modules forming one room

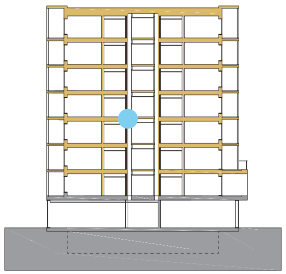




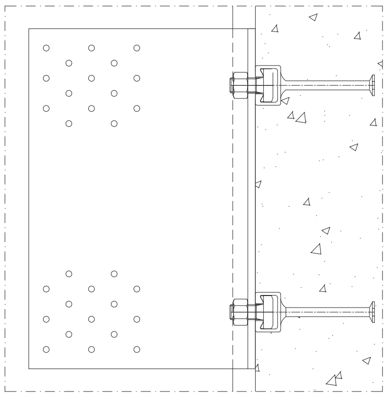
Exact amount, size and spacing of fastener according to structural engineer.

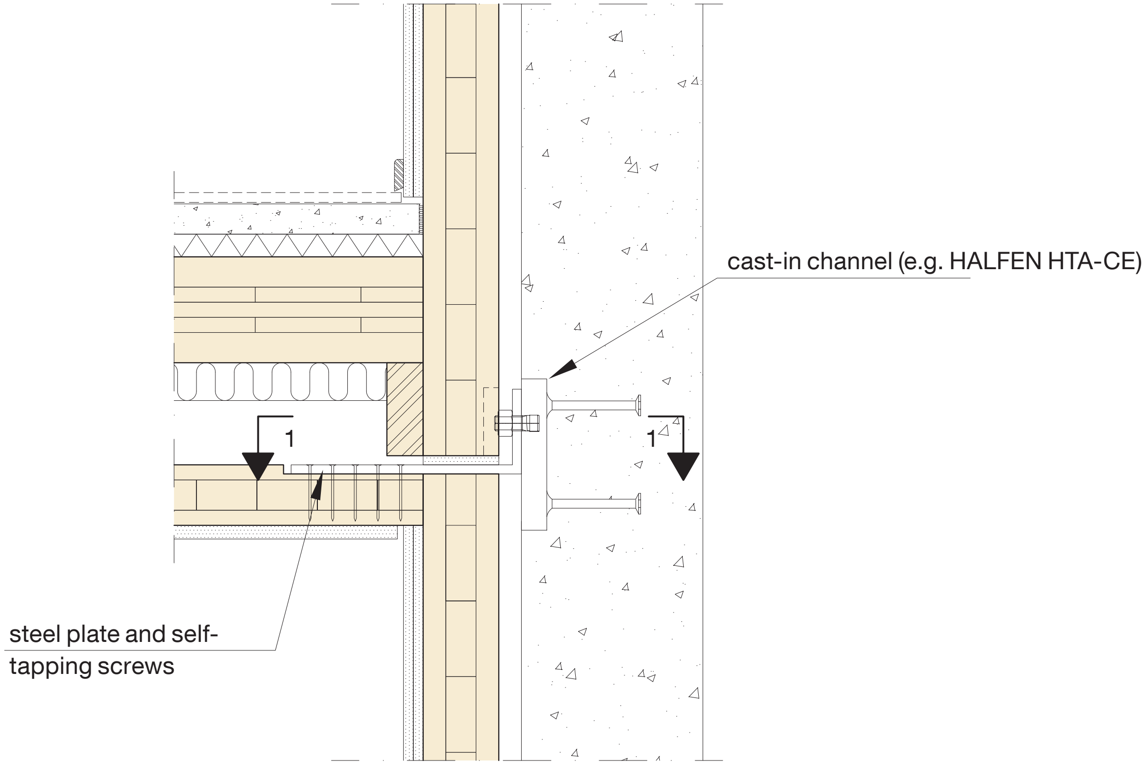
VD 16 A

Intermediate floor to concrete wall, apartment



1 – 1

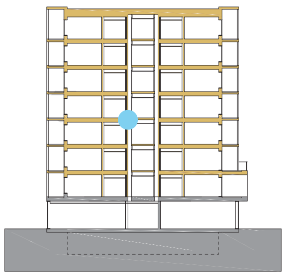




Exact amount, size and spacing of fastener according to structural engineer.

VD 16 A

Intermediate floor to concrete wall, apartment



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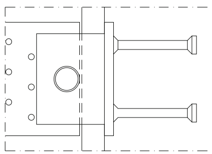
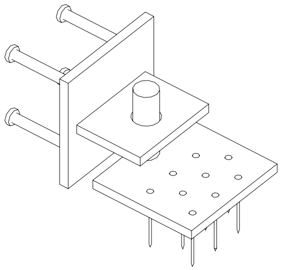
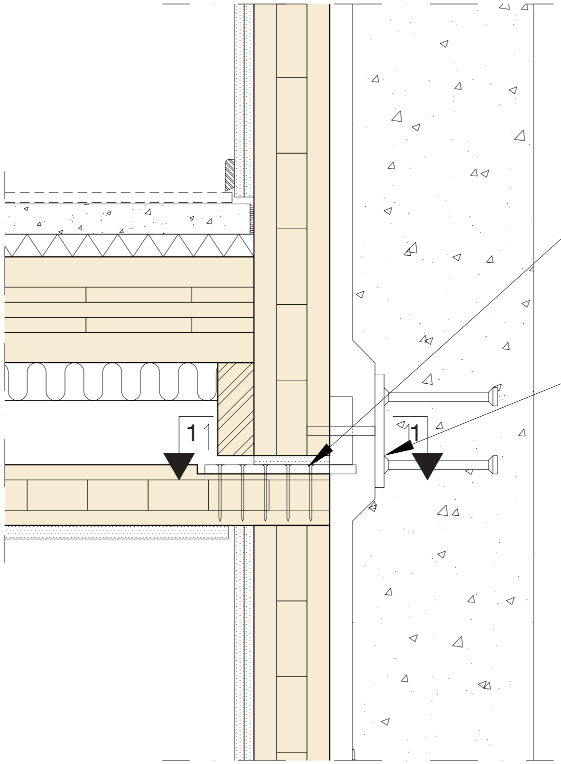


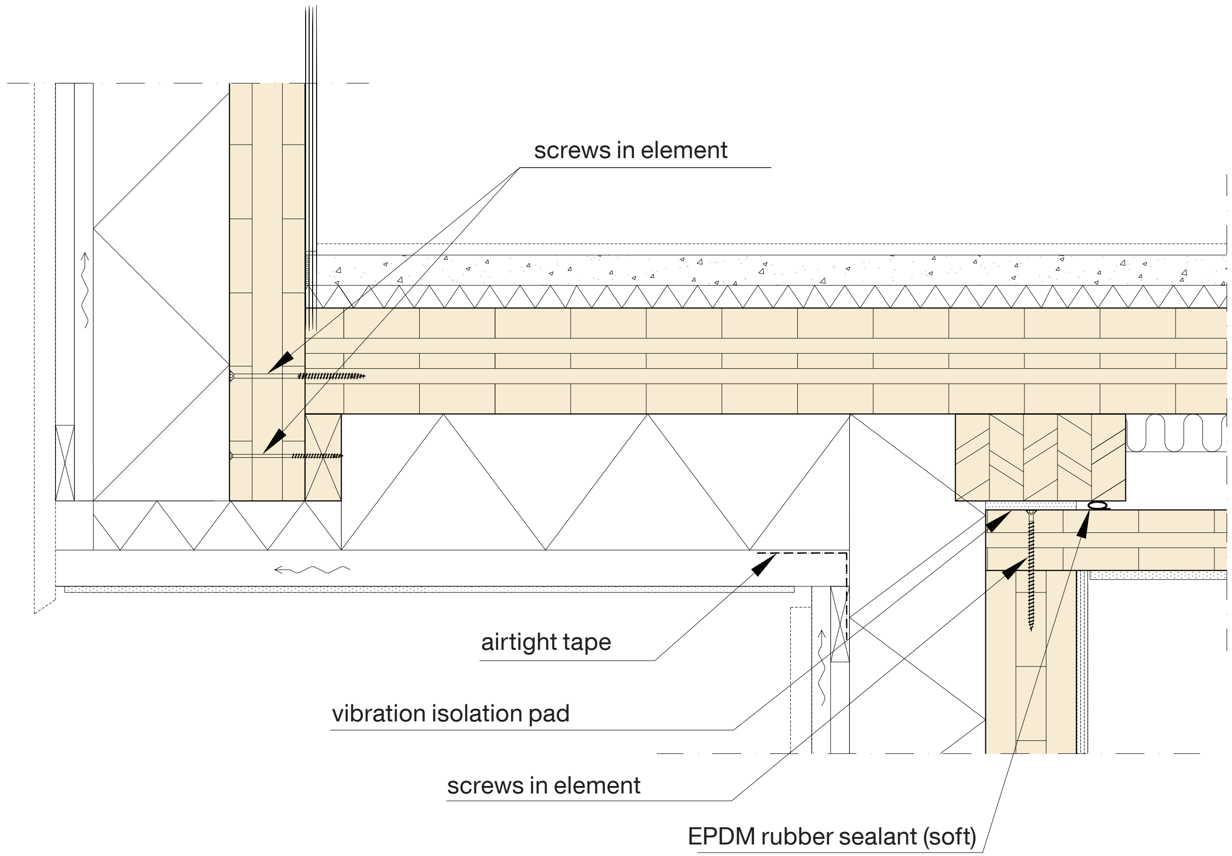


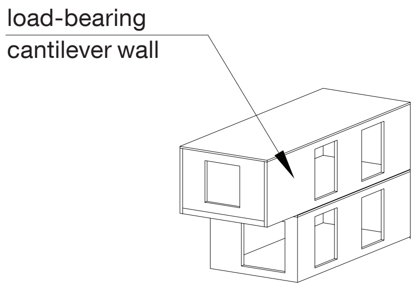


Exact amount, size and spacing of fastener according to structural engineer.

VD 17

Intermediate floor to external wall, cantilever apartment

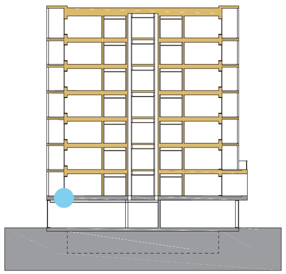


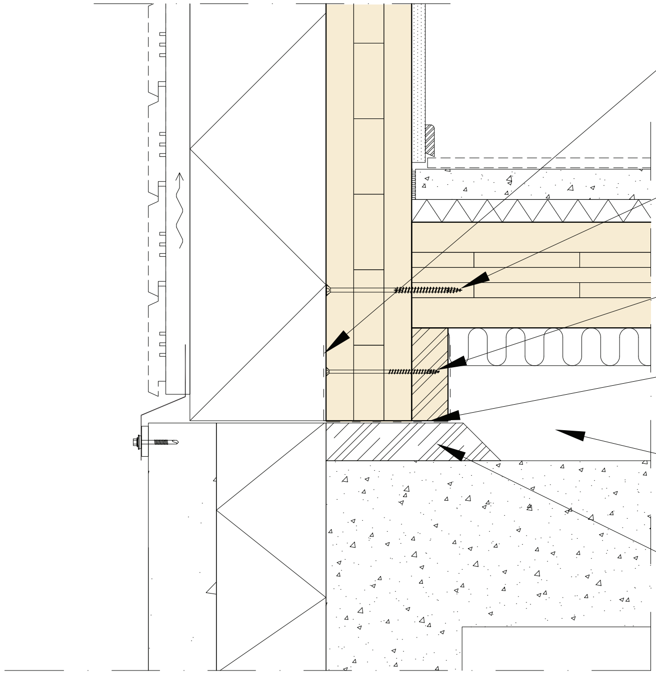


Exact amount, size and spacing of fastener according to structural engineer.

FD 1

External wall to ground floor, apartment

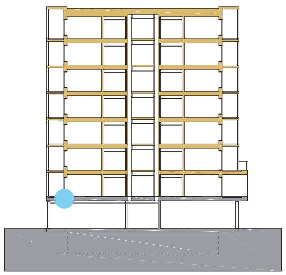


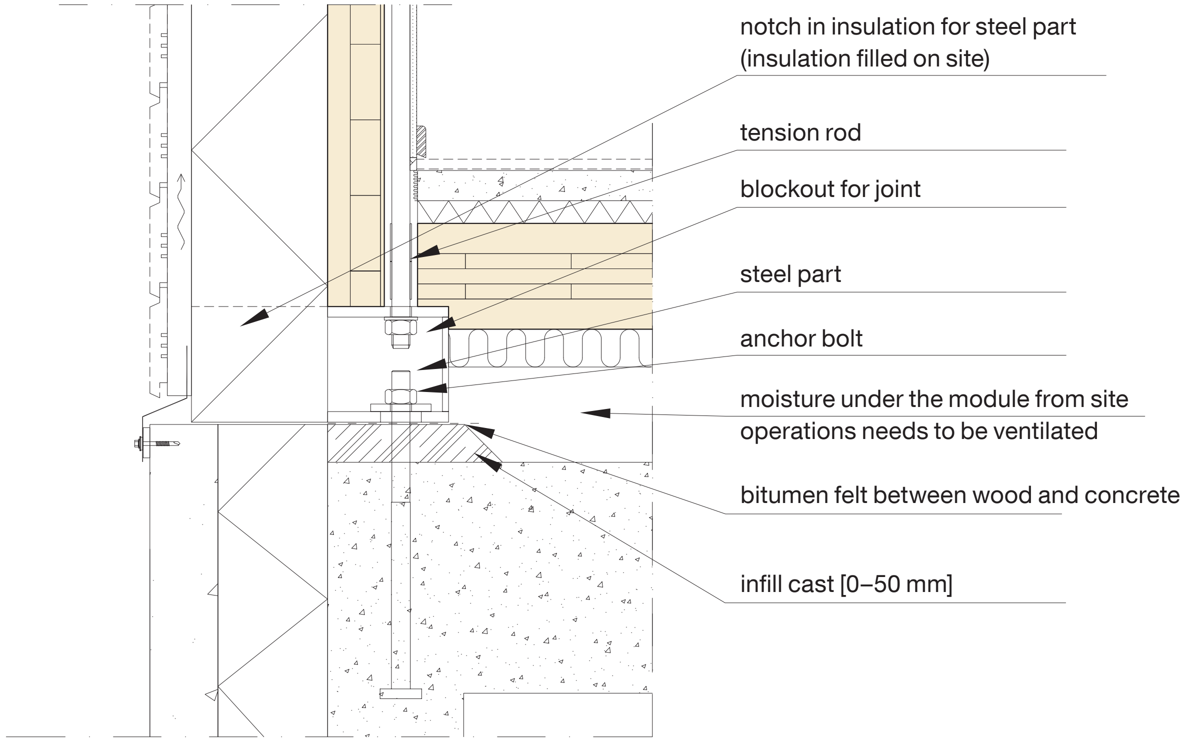


Exact amount, size and spacing of fastener according to structural engineer.

FD 2

External wall to ground floor, uplift tie

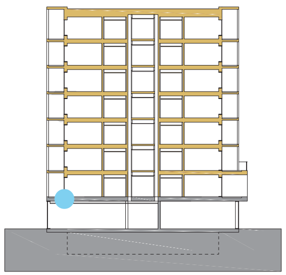


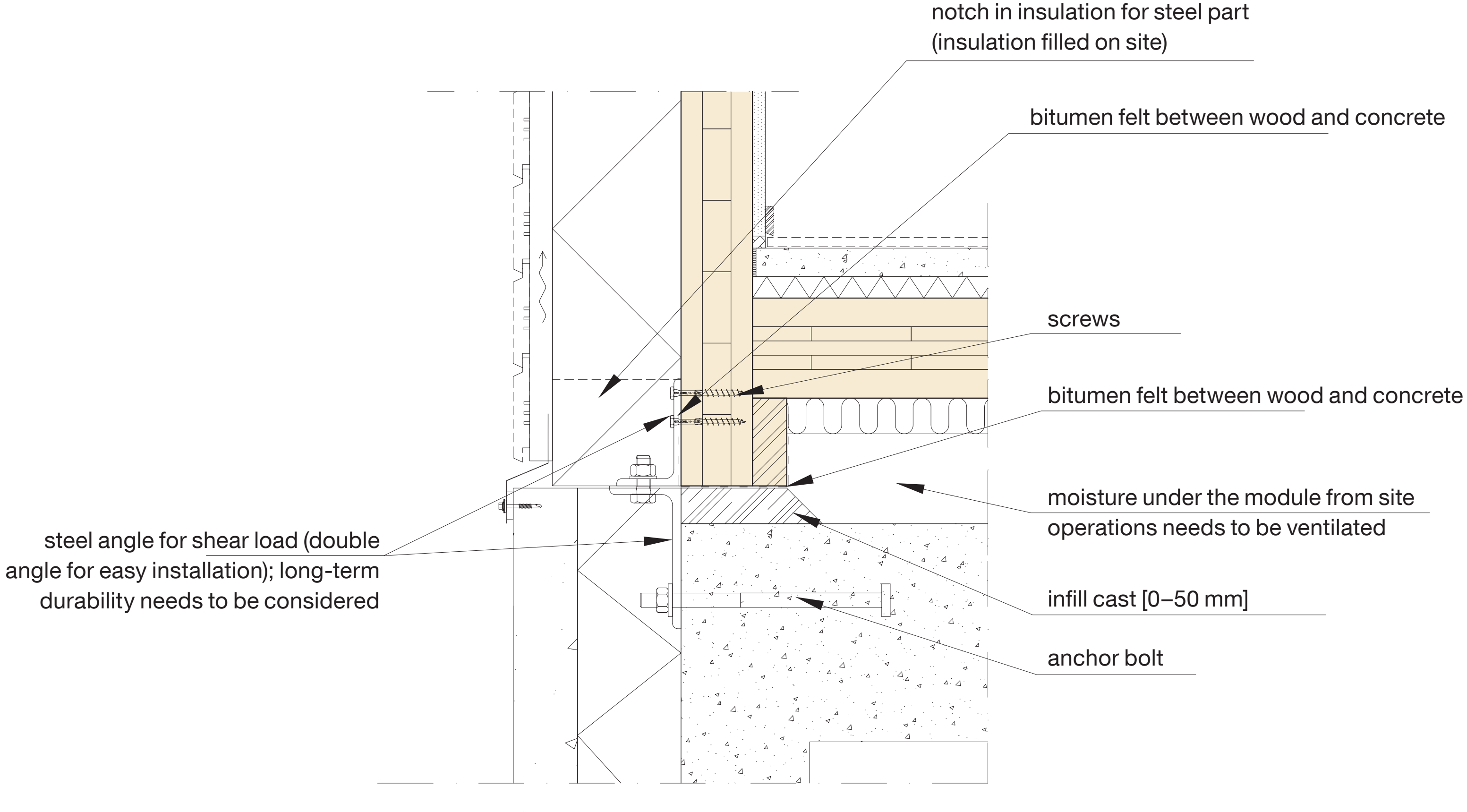


Exact amount, size and spacing of fastener according to structural engineer.

FD 3

External wall to ground floor, shear transfer

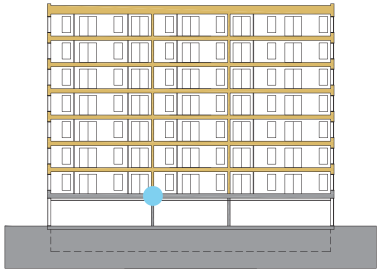


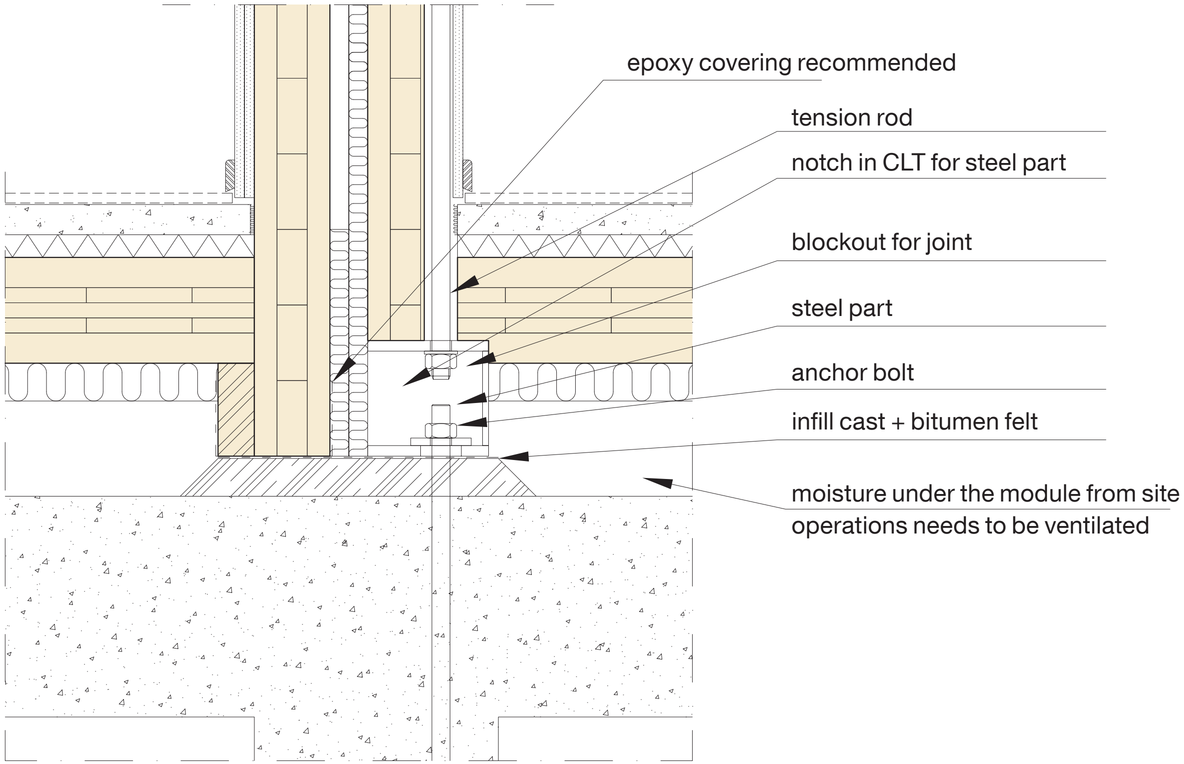


Exact amount, size and spacing of fastener according to structural engineer.

FD 4

Partition wall to ground floor, uplift connection

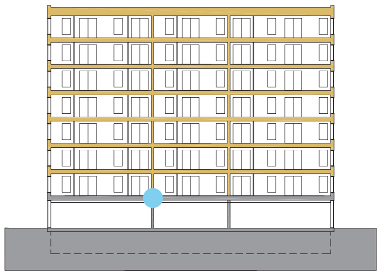


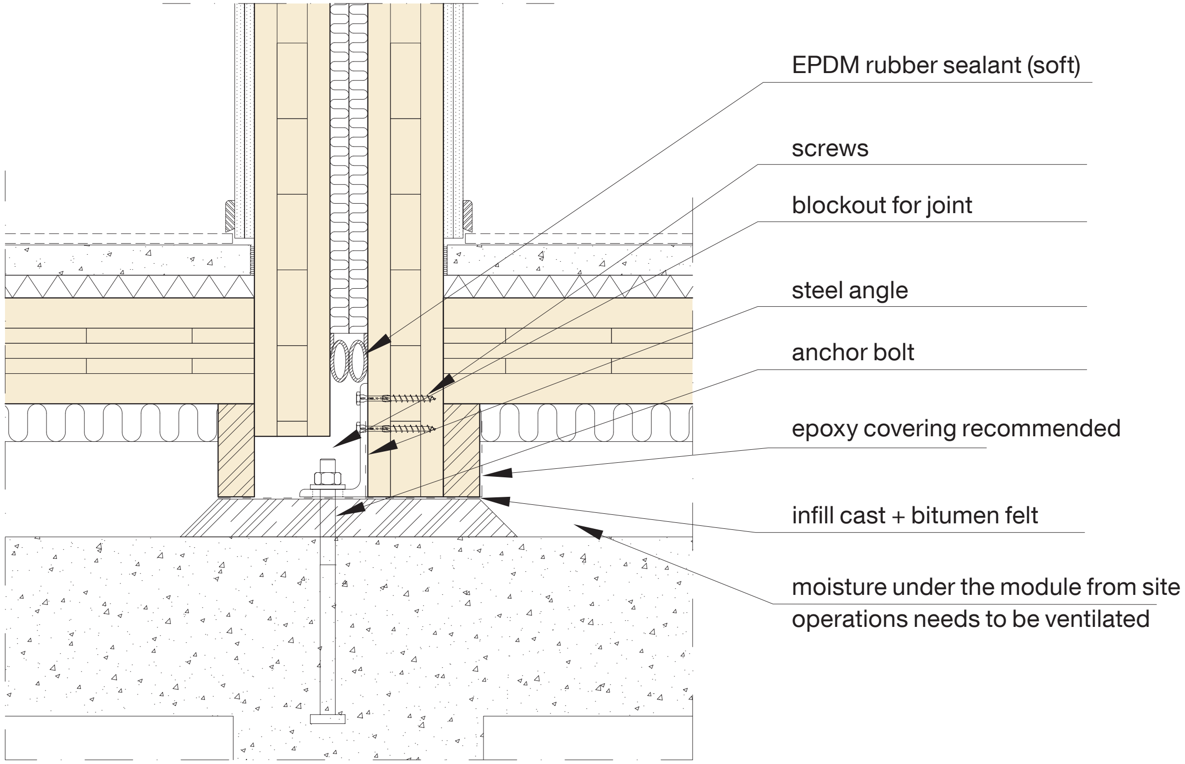


Exact amount, size and spacing of fastener according to structural engineer.

FD 5

Partition wall to ground floor, shear connection
(may also be calculated to take uplift)

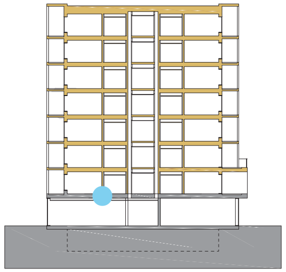


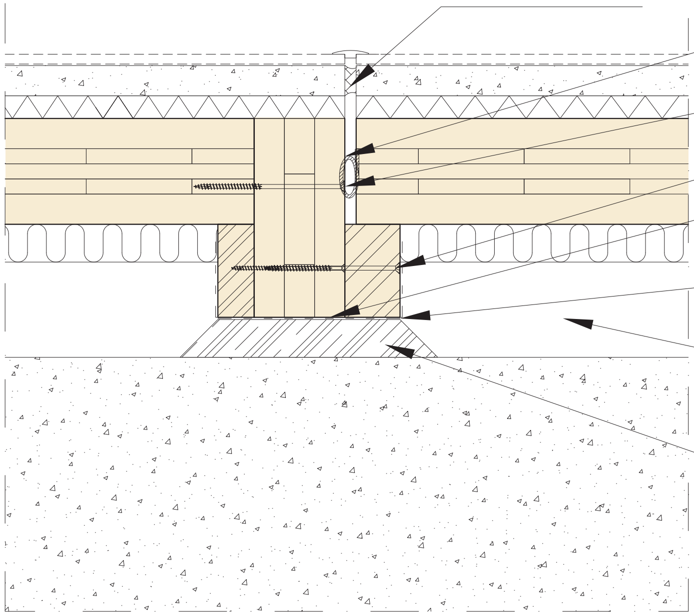


Exact amount, size and spacing of fastener according to structural engineer.

FD 6

Partition wall to ground floor, inside apartment



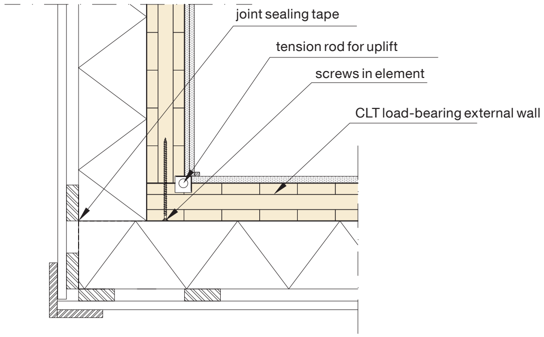


Exact amount, size and spacing of fastener according to structural engineer.

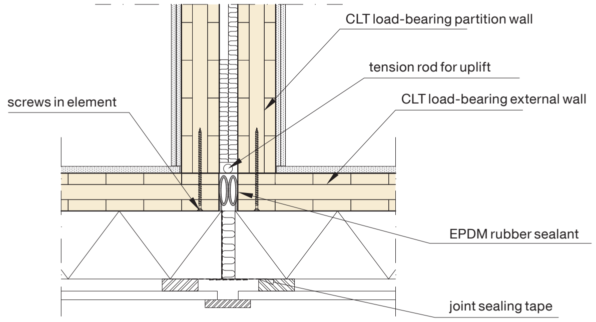
HD 1–3

Horizontal details

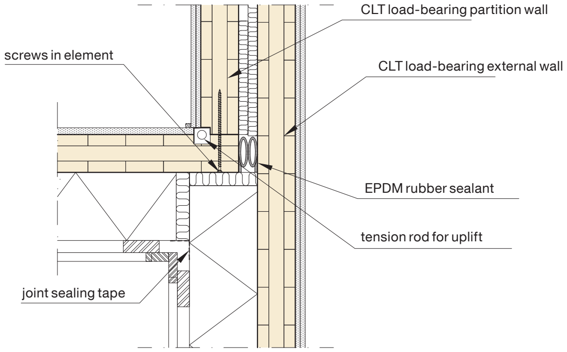
HD01 Salient corner

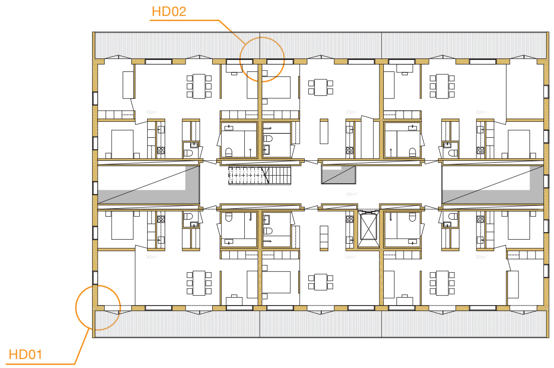


HD02 T-connection



HD03 Re-entering corner





Exact amount, size and spacing of fastener according to structural engineer.

6 Transportation and instructions for on-site assembly

6.1 Transportation of modular elements

- Finished modular elements are protected in factory with plastic outer cover and then lifted to truck.
- Modular elements are fastened to the trailer during transport in order to prevent movement and damage.
- Elements are transported from the factory to the building site for the installation. Before transportation, it has to be made sure that the transportation route is suitable (checking for low bridges or tight corners on the route).
- Local traffic legislation may limit the size of modular units according to maximum width and height of transportation loads.

6.2 Principles of erection

6.2.1 General

- An erection scheme must be made and approved according to the local building regulations before starting erection.
- Before beginning, ensure 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.
- Modular elements may be lifted from 4, 6 or 8 lifting points depending on the element.
- Lifting points must be planned so that they can carry the weight of the modular element.
- Lifting points must be planned to keep the module balanced while it is lifted.
- Modules with large openings need to be reinforced before lifting to prevent deformation and damage.
- 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.
- Typically the erection speed of modular units is 6 units/shift.

6.2.2 Installation of modular elements

- The erection surface must be checked before starting erection — straightness, tolerances, etc. should be confirmed.
- Modular elements should be unloaded in order of assembly or installed directly from the truck.
- Modular elements are prepared for lifting (plastic covers are removed from the area where they are not needed). Before installation a visual check should be done to verify quality of the elements.
- Each modular element is lifted on its spot. Guiding steel parts should be used to get the modular element to the right spot and to stay within installation tolerances.
- Once it is ensured that the place and position of the modular element is within tolerance, it can be permanently fastened. Fastening of concealed steel parts should be documented during installation.
- After the installation of adjacent modular elements, joints must be sealed.
- Once all modular elements of one floor are erected, other structural elements such as beams, posts and CLT slabs which are not included in modular elements can be installed.
- Visual check of the whole floor should be carried out before moving on with the installation.
- The structure must be stabilized before starting installation of the next floor.

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 moisture 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 must be documented.

6.4 Protection of structures and material on-site

- All modules should be entirely protected during the transportation and installed as they arrive on site or stored without direct contact to the ground.
- All modules will be inspected from outside before erection. Any damages incurred will be documented and repaired immediately.
- The erection sequence of modules will be planned so that modules can be protected after erection. All modules under one roof module should be erected at one time (Fig. 1).

6.4.1 Protection of walls in modular elements

- At the factory, modular elements are covered with a plastic coating which is partly removed on-site before erection.
- The connections between modules on external walls of the building are protected by taping the joints with applicable tape and installing a divider plank on façade boarding.
  - External walls of the modular elements that are not a part of the building façade have to be protected until adjacent modular elements are installed.

6.4.2 Protection of roofs in modular elements

- Modular elements are protected on top with temporary roof modules (Fig. 1), which can cover one or multiple apartments.
- The roof modules are equipped with a beam for lifting.
- The roof elements are often made of gang nailed timber trusses, chipboard and a bitumen layer.
- Joints of the roof modules are protected by overlapping the bitumen with the adjacent roof module.
- Sides of the roof modules are protected with boards or plastic covers so that rainwater will not leak into the module structures.
- The roof modules can be equipped with channels for controlling drainage.
- Cantilever modular elements that are not protected by roof modules need to be protected with a tarpaulin or other protective material.

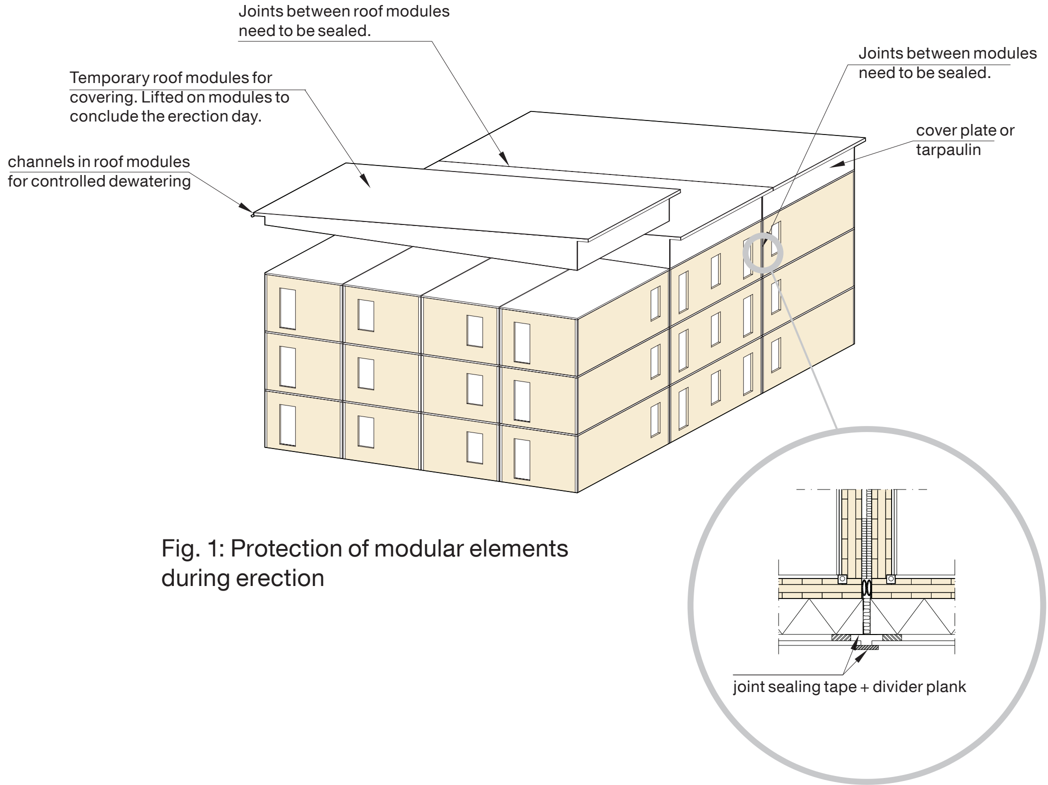


Fig. 1: Protection of modular elements during erection

6.4.3 Management of the indoor conditions

- The management of indoor conditions will begin when load-bearing structures are erected and openings in external envelope have been covered.
- The heating system is set to every space enclosed by load-bearing walls, in order to dry structures.
- It is recommended to use two recording condition loggers (to measure relative humidity and temperature of the air). This is to ensure drying of the structures in every separate space. Data collected from condition loggers should be unloaded every week and management of indoor conditions will be proceeded based on the information from this data. During site assembly, it is recommended that the relative humidity of the air is kept under 75%. After installation of thermal insulation, the relative humidity of the indoor air should be under 45–55%, with a temperature higher than +10 °C in order for structures to dry effectively.

6.4.4 Inspections to be made before installation of finishes

These principles are applied to areas that are not prefabricated modular elements.

- The moisture content of all internal structures should be inspected before installation of internal coatings begins.
- The condition of all internal wood surfaces should be checked with appropriate instruments.
- The moisture content of all 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 coatings 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 and weighing measurements as well as by measurements of the relative humidity of the pore-air of the timber.

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/m²K 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.

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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.

rethink.

storaenso

Stora Enso
Division Wood Products

Building Solutions

Email: buildingsolutions@storaenso.com
www.storaenso.com
www.clt.info

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