KLH®

MADE FOR BUILDING
BUILT FOR LIVING

BUILDING SYSTEM

MULTI-STORY RESIDENTIAL BUILDINGS

IMPRINT

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CONTENT

01 INTRODUCTION 02
02 SYSTEM 04
03 STRUCTURAL CONCEPT 10
04 FIRE PROTECTION CONCEPT 12
05 BUILDING SERVICES CONCEPT 14
06 SOUND INSULATION CONCEPT 16
07 DETAIL PLANNING 19

BUILDING-SYSTEM

FOR MULTI-STORY RESIDENTIAL BUILDINGS

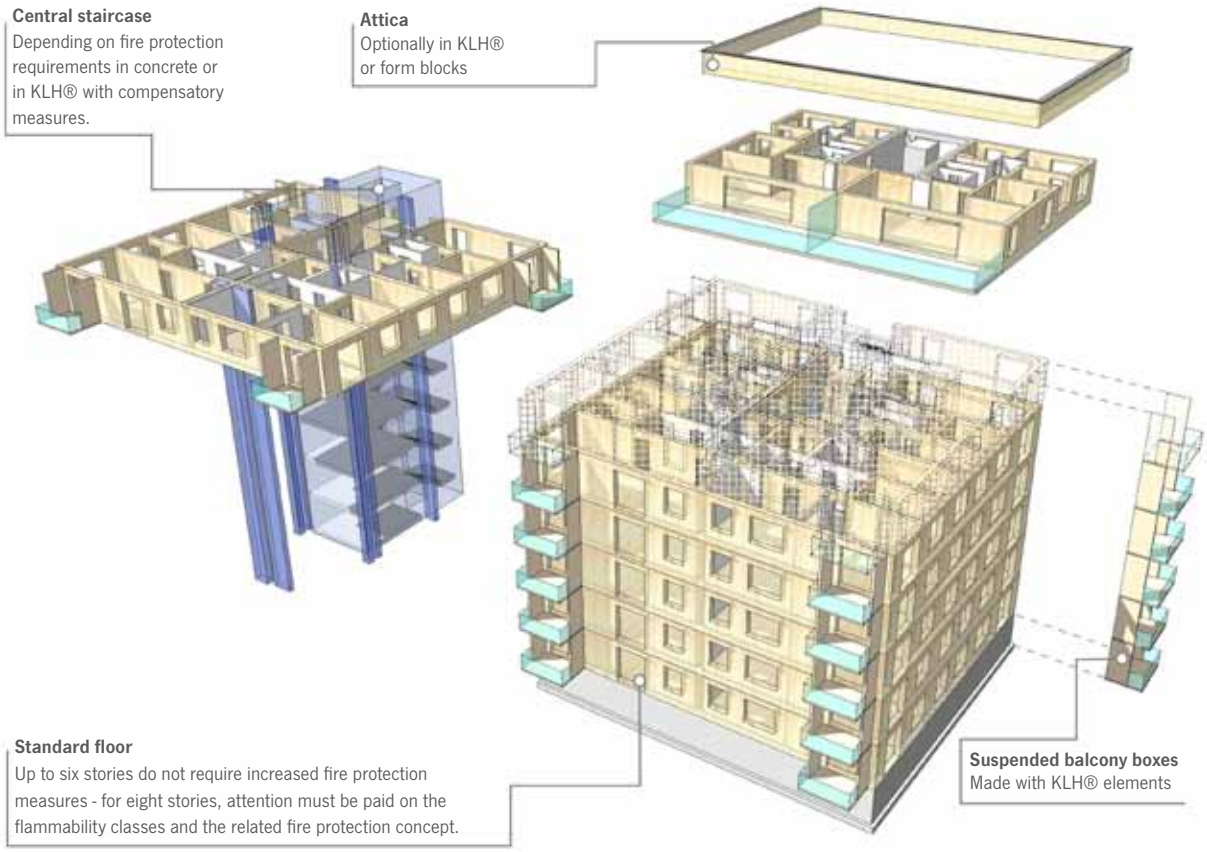
Building with a system is an important success factor, especially in timber construction. The diverse and natural advantages also bring with them a necessary degree of care that the long-term use of timber material demands. In the meantime, timber buildings have found their way into almost all areas of building construction and have to compete with other building structures.

Mass timber construction with KLH® elements offers a very wide range of possibilities in which projects can be realized.

The booklet Building System tries to offer clients and planners a possible tool for economic, functional and flexible solutions. Based on these system principles, projects can be developed with planning certainty and the advantages of solid timber construction.

KLH
© Will Pryce

02 SYSTEM



DEVELOPMENT

Due to fire prevention, a difference is made between buildings up to 6 stories and up to 8 stories (high-rise limit).

The basic concept deals with a non-visible variation with a typical KLH® support structure, which focuses on a solution that is as economical and simple as possible. Approaches to other variations are also discussed. By default, a concrete staircase is used, but the possibility of a mass timber staircase is already considered in the fire protection concept.

As this is the primary escape route, the criterion A2 „non-combustible“ is applicable here. In addition, the stiffening function can be used to simplify the static concept.

Furthermore, the following documents are available:

- A structural concept for the basic version
- A fire protection concept coordinated with the OIB guidelines for the optimal use of timber
- An example for planning the building services
- The tested sound insulation solutions from KLH® (nodes/joints and build-ups)
- A detail catalog for the most important interfaces

BASICS

The current technical KLH® documents are available online as a basis for project planning and a detailed coordination. For structural design and fire protection, the ETA 06/0138 is the most technically relevant document. In order to better understand the values listed in the following chapters or to optimize them for a new project, the specially developed dimensioning tool (KLH-designer) can be used.
The advanced building physics is covered by numerous investigations in the field of sound insulation and by detailed elaboration.

REQUIREMENTS FOR BUILDINGS

STRUCTURAL DESIGN

The structural requirements, according to the design standards valid in Austria, are considered in the chapter regarding the structural concept.

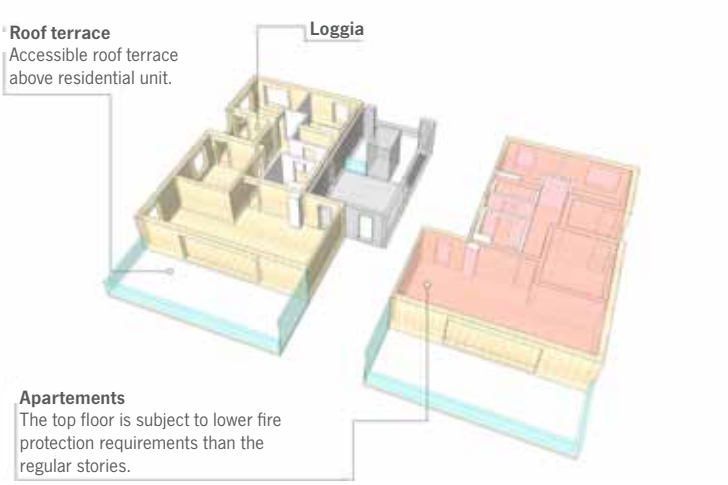
FIRE PROTECTION

The requirements regarding fire protection are based on the Austrian OIB guidelines. These classify buildings, such as the one examined in the system, into building class 5. More detailed information on the requirements of building class 5, as well as on the adapted concept solutions, can be found in OIB guideline 2 and in the chapter on the fire protection concept.

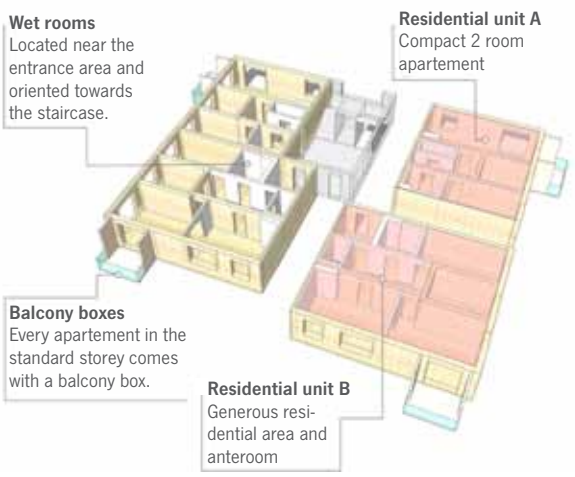
THERMAL PROTECTION

The individual system components, which in principle aim at a typical new building, are oriented towards the design of a low-energy building. To ensure the associated heating energy demand, an overall assessment of the insulation thicknesses, the building components not considered in detail here (doors and windows) and the building technology systems involved must be carried out. Protection against overheating in summer, regarding the non-opaque building components, is a very individual plannings aspect and is not explained in detail.

APARTMENT FLOOR



4 UNIT FLOOR / REGULAR FLOOR



BUILDING CLASS 5	
Finished floor level above 11 m until max. 22 m Does not belong to building class 1 to 4, no special building	

MOISTURE PROTECTION

Moisture protection is to be ensured by the appropriate choice of details and by up-to-date standards. For the roof, the plinth and various connections, the necessary elevations and waterproofing levels must be as specified in the detailed catalogue and in relevant literature, as well as the KLH® construction documents.

SYSTEM VARIATION

In addition to the elaborated basic variation, adaptions are also possible. Depending on the building typology, this requires more or less adaptation of the details and the overall concept.

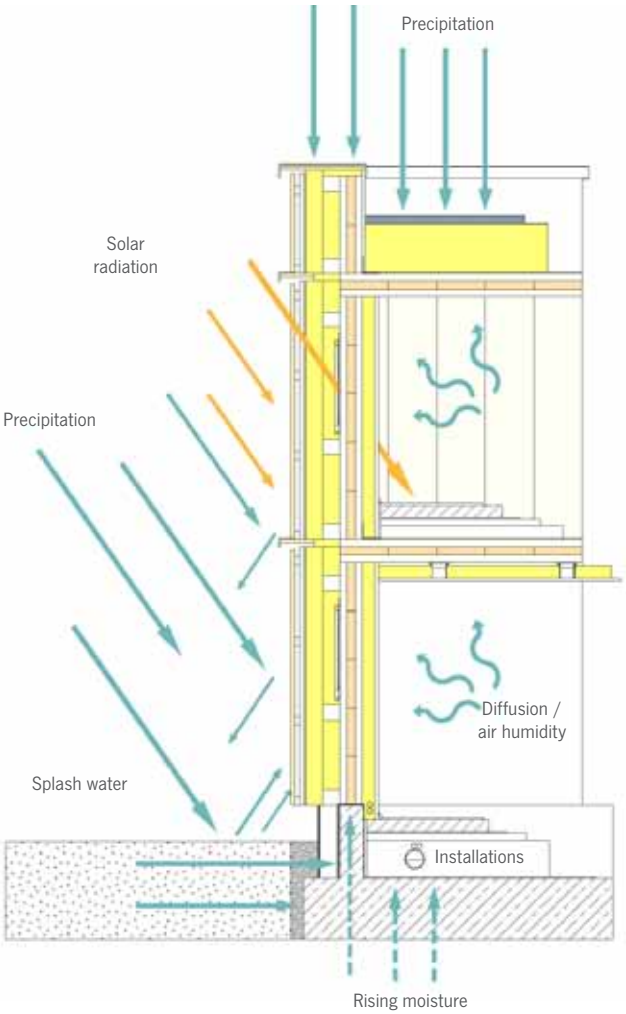
BASIC VERSION

The basic version is based on a purely non-visible structure in which the load-bearing walls are covered with facing formworks and all ceilings are suspended. This variation offers clear technical advantages and is easy to implement. Due to the complete shielding of the joints from unwanted sound transmission via the flanks, continuous floors as well as joints without decoupling are possible. Fire protection plankings reduce the necessary cross-sections of the load-bearing walls to the structural requirement. Installations can take the simplest route in the easily accessible facing formwork in front of the load-bearing walls and therefore do not require any additional trimming.

ADVANTAGES

- No joint decoupling for sound insulation requirements
- Template to design the building services
- Simplest initial situation for installation
- Fire protection of the walls can be incresed with the facing formwork

STRESSING OF THE FACADE



EXAMPLE BASIC VERSION

© Bert Leandersson

DISADVANTAGES

- No visible load-bearing wooden components
- Possible loss of area due to facing formworks

VSISIBLE CEILINGS

Visible or directly planked ceiling surfaces are still relatively easy to achieve. For this, continuous ceilings over separate units should be avoided, but this leads to lutely certain (depending on the requirements) and can be compensated, if necessary, by conditioning the ceiling element. A comprehensive consideration of all flanking components as well as a ceiling structure designed for this is necessary.

An advantage is offered by Timber-concrete composite ceilings, which already ensure a lower flank transfer due to their higher mass. Facing formwork on the outer walls are not necessarily required here; a joint decoupling on the floor slab compensates the vertical flank transmission. Attention must be paid to the connection between outer walls and partition walls.

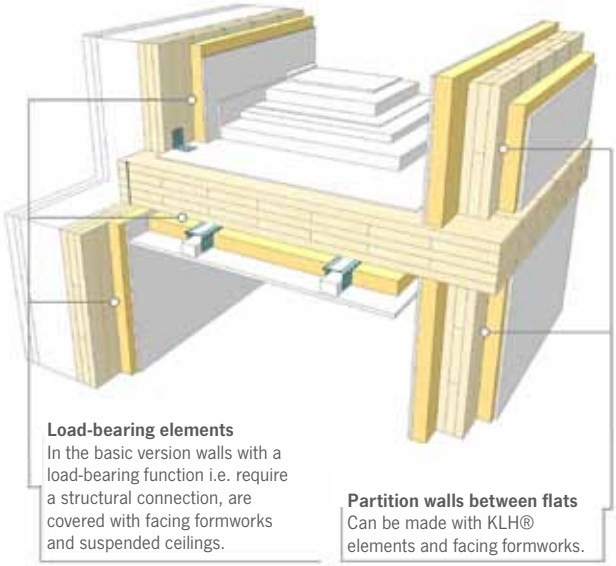
ADVANTAGES

- Visible ceiling possible
- No suspended ceiling necessary
- Mostly no facing formwork on load-bearing elements

DISADVANTAGES

- Continuous floor slabs are limited possible
- Compensation of the omitted facing formworks with separation by elastic bearings
- More detail planning of the junctions required
- Slightly increased assembly effort due to higher number of elements

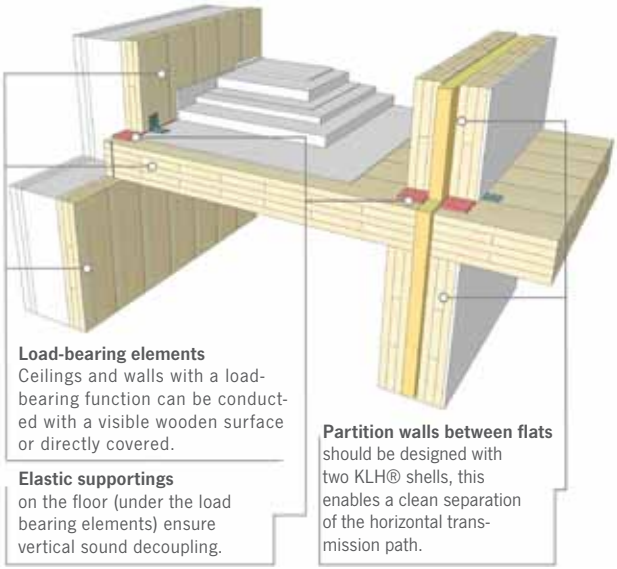
BUILDING PARTS BASIC VERSION



EXAMPLE VISIBLE CEILING

© Christian Lohfink – Planpark Architekten

BUILDING PARTS VISIBLE CEILING



TIMBER FRAME WALLS

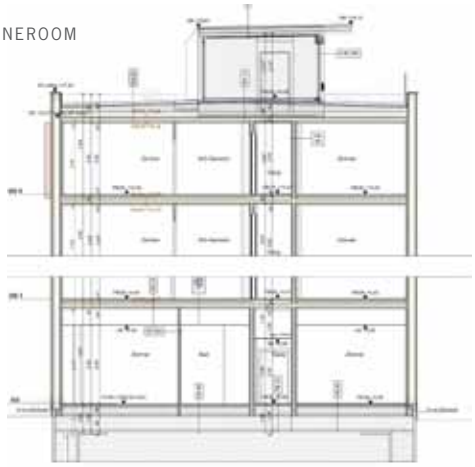
Mixing KLH® - CLT elements with timber frame walls can, with the correct planning and the necessary resources, be an economic solution for a high degree of prefabrication and optimized joint details. The lower sensitivity to flank sound transfer in timber frame walls can add a significant value to the exterior walls if the details are properly designed.

In the case of ceilings and load-bearing interior walls, the shorter assembly time as well as the structural and building physical properties are clear advantages of Cross laminated timber elements. With this system, an increased planning effort and more needed know-how must be expected. However, if the system is used correctly, this can pay off in terms of material and assembly costs.

MINEROOM LEOBEN

© J. Konstantinov

SECTION MINEROOM



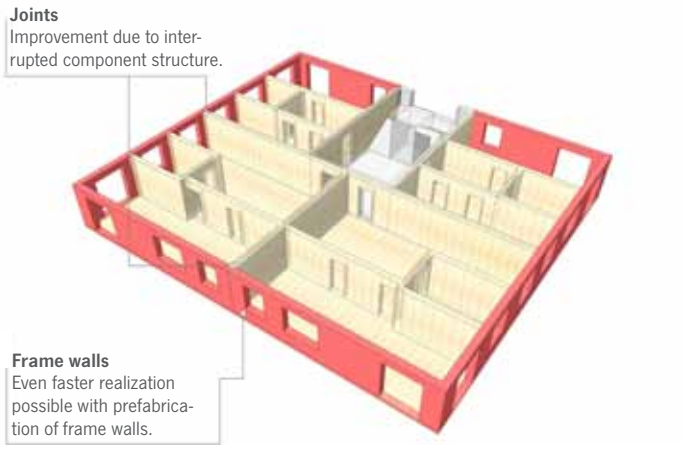
ADVANTAGES

- High degree of prefabrication of exterior walls
- Decoupling of the exterior walls can be reduced to a minimum, regardless of the ceiling construction

DISADVANTAGES

- More complex stability and structural design
- More detail planning required
- Higher accuracy and more optimized time management is necessary during assembly

EXAMPLE EXTERIOR FRAME WALL



INCREASED SPAN WIDTH

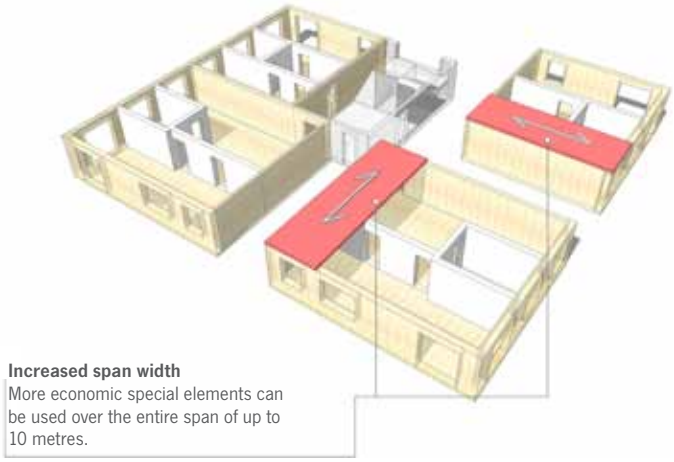
Increased spans can also be covered with other element combinations instead of thicker KLH® - CLT elements.

RIB ELEMENT

A material-saving solution that can be obtained directly from KLH® would be rib elements. The cross-section-height will inevitably be somewhat higher, but the space in between can, depending on the rib situation, already be used for sound insulation or as installation space.

TCC-ELEMENT

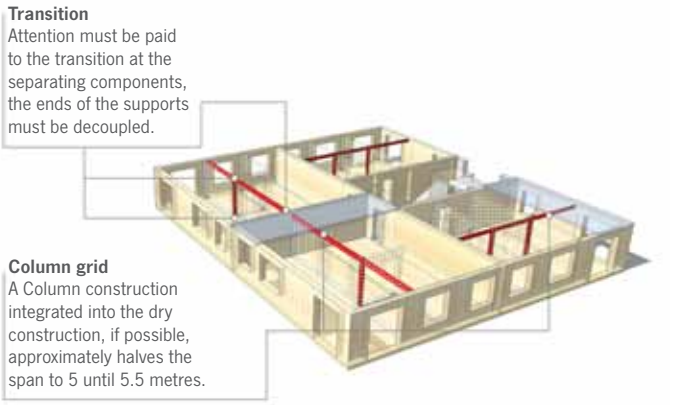
TCC-Elements can also provide an increased value for optimal project realization. The advantages and design options can be found in the KLH® TCC booklet. This variation makes sense, especially for continuous ceilings and as fire protection compensation.



BOX ELEMENT

KLH® - box elements are often a combination of ribs, on top or underneath the element and a thinner layer to close the cavities. These cavities, similar to non-closed ribbed elements, are available for various installations and sound insulation measures. Box elements are particularly suitable for integrating mass (e.g. fill) and dampers into the elements.

Column grids or beams can also be an option to reduce the spans and still achieve the highest possible space gain with typical slab cross-sections. The additional assembly effort and the decoupling of the transitions to neighbour units must be taken into account.



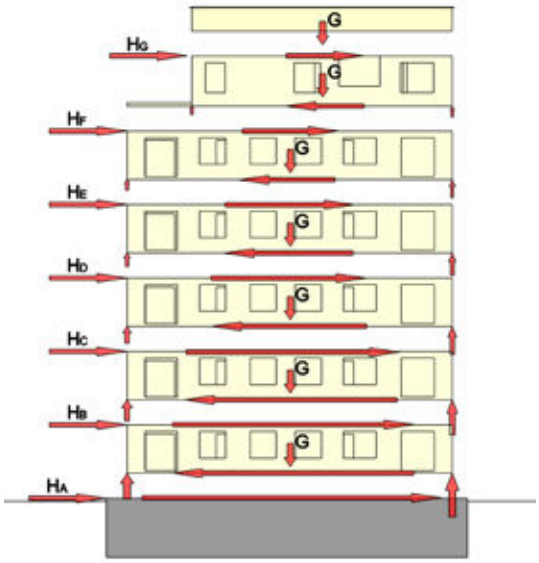
03 STRUCTURAL CONCEPT

INITIAL SITUATION

The central staircase core is used as a stiffening element made out of reinforced concrete in the standard version. Adapted variations can also be connected to it. The flexible basic floor plan is oriented towards a span width around 5 metres, with simple KLH® single span beams. The components are pre-dimensioned to the ultimate limit state (ULS) as well as to the serviceability limit state (SLS).

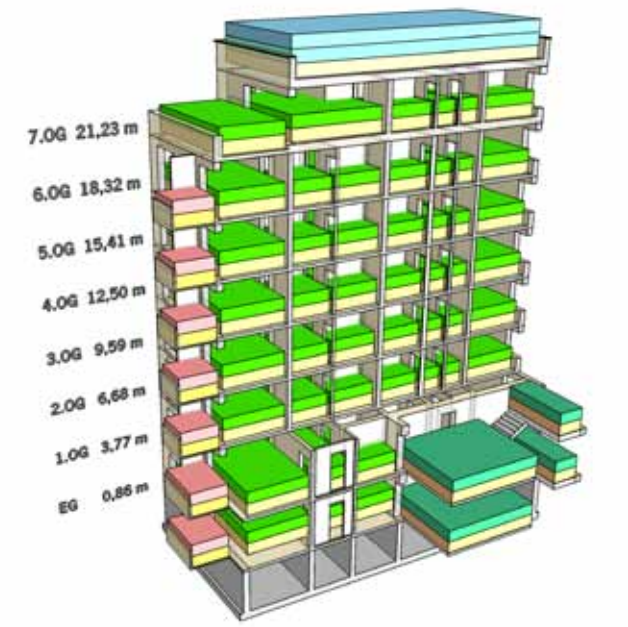
ETA-06/0138 and the valid versions of the following standards were used as basic documents:
ÖNORM EN 1995-1-1, ÖNORM B 1995-1-1
ÖNORM EN 1995-1-2, ÖNORM B 1995-1-2
In addition, the KLHdesigner is available on our homepage www.klh.at/en or can be found directly via www.klhdesigner.at.

STABILITY / FASTENERS



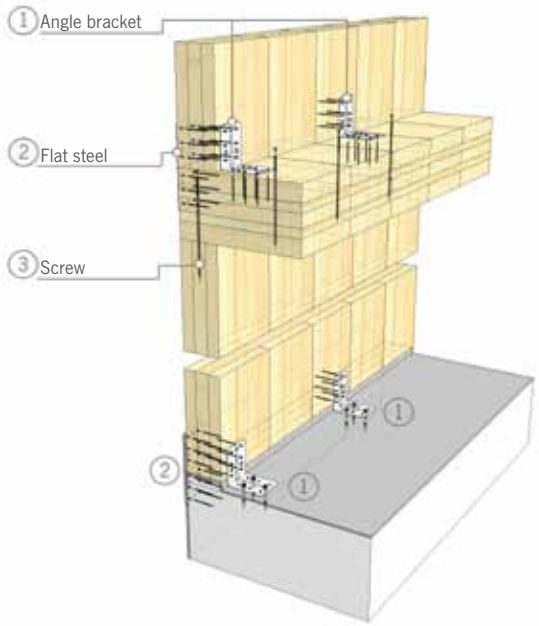
LOAD ASSUMPTIONS

According to ÖNORM B 1991-1, ÖNORM EN 1991-1
Building Length: 22.5 m
Building Width: 19.6 m
Building Height: 24.9 m



Examples for increased requirements (earthquake area)

TRANSITION JOINTS / CONNECTION TO THE FOUNDATION



UTILIZATION

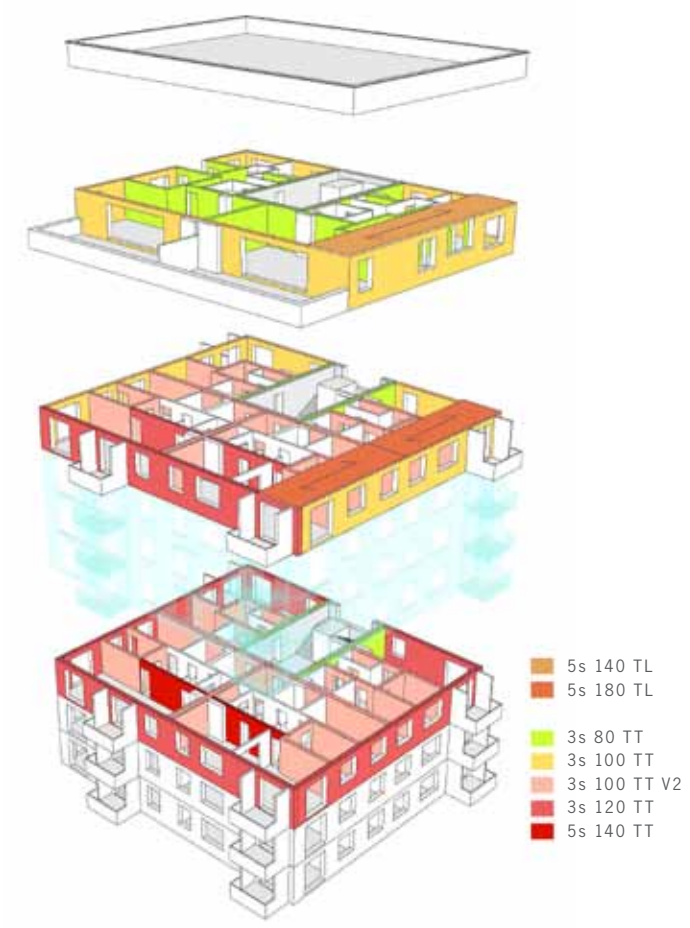
ROOF
KLH® 5s 140 TL
REI 60
max. 82% utilization

WALLS 7.OG
KLH® 3s 80 / 100 TT
REI 60 incl. covering
max. 25% utilization

STANDARD FLOOR
KLH® 5s 180 TL
REI 90 incl. covering
max. 79% utilization

WALLS 3. FLOOR - 6. FLOOR
KLH® 3s 100 / 120 TT
REI 90 incl. covering
max. 68% utilization

WALLS GF - 2. FLOOR
KLH® 3s 100 / 3s 120 TT
KLH® 5s 140 TT
REI 90 incl. covering
max 87% utilization

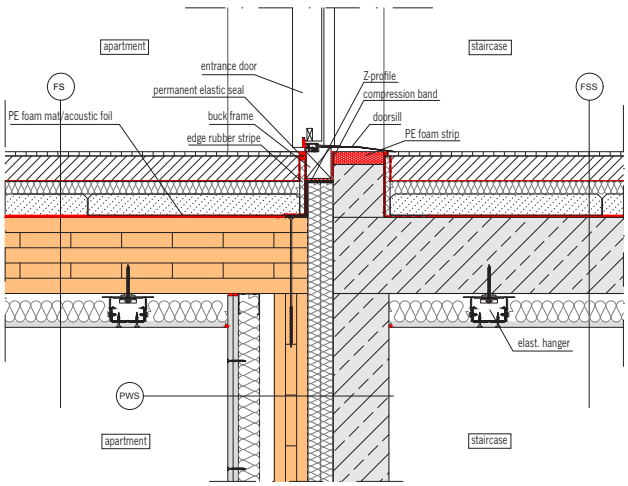


SETTLEMENT

As there is a standard transition between concrete (staircase) and Cross-laminated timber as a load-bearing element, a difference in settlement is to be expected depending on the number of stories. The total difference, resulting from a possible wood moisture change of approx. 4%, yields in about 20 mm on the top floor (depending on the actual starting material).

This change in height must be absorbed by suitable methods, such as flexible transitions.

CONNECTION TO THE STAIRCASE



04 FIRE PROTECTION CONCEPT

BASIC FIRE SAFETY FOR TIMBER CONSTRUCTION

With the increasing popularity of timber construction, not only the timber builders themselves but also the responsible authorities and the industry specializing in detail solutions have taken a closer look at the topic of fire safety in timber construction.

In recent years, regulations and national specifications have been largely adapted and revised for mass timber construction. Fire protection technology that is dependent on construction methods (fire dampers, fire doors, fire protection aprons) is now also available with the corresponding detailed descriptions.

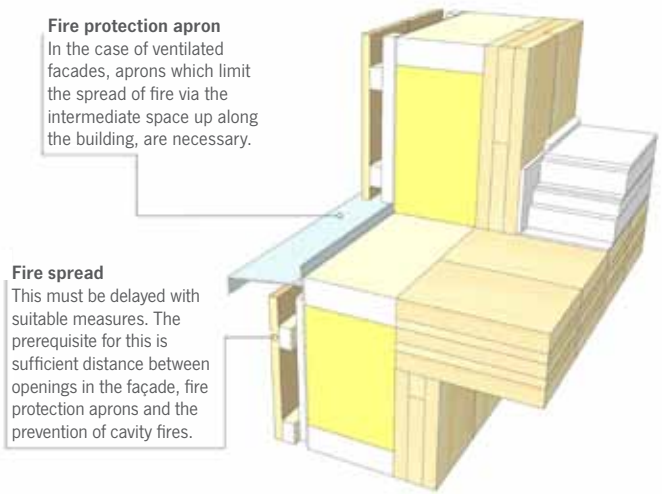
Relevant literature now offers solutions for penetrations, cavities and protection against flashover.

Three key criteria influence the resistance of building materials and components to the effects of fire, R (Résistance), E (Etanchéité), I (Isolation). Solid wood panels can quickly convince in the criteria E and I.

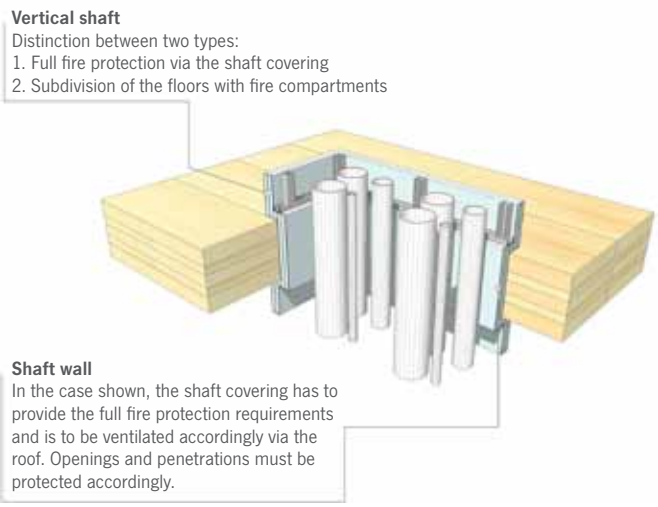
Since wood has a relatively high thermal insulation effect (increases even more in case of fire due to the pyrolysis) and also remains sealed over a long period of time, it can be assumed that the load-bearing capacity R will fail before the other two criteria.

On the other hand, wood is also reliable in terms of load-bearing capacity in the event of fire. It enables a relatively precise prediction of possible failure occurrence due to extensively tested burn rates and residual load-bearing capacity of the remaining cross-section.

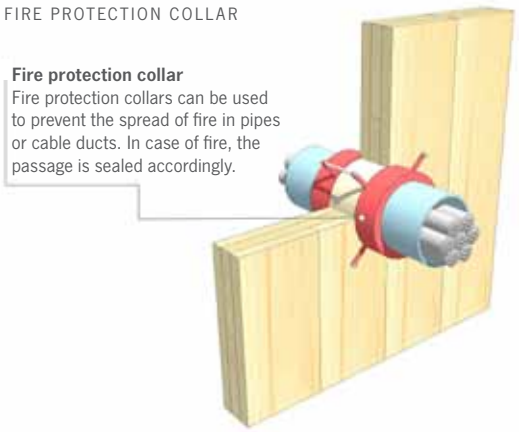
BRANDSCHUTZSCHÜRZE



SHAFT COVERING



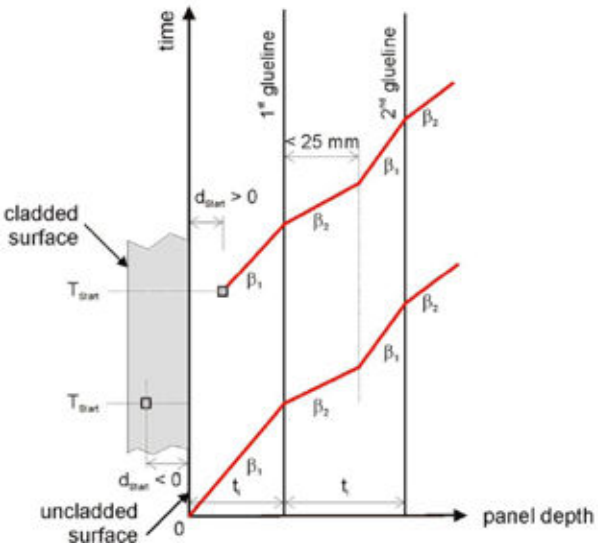
FIRE PROTECTION COLLAR



SYSTEM KLH®

According to Eurocode, the engineer has two options for calculating fire protection. The simpler and therefore more common method is the reduced residual cross-section method. The second option, which KLH® calls „System KLH®“ due to intensive research and development in this field, refers to reduced properties.

Basis for the application of this method, which is specially designed for KLH® panels, is ETA 06/138, which contains the procedure and the test results prepared for it. Various KLH® information materials and the KLHdesigner, an interactive software tool for evaluating fire-stressed components, are available online for a better understanding and easier handling.



CONCEPT

The calculated fire protection represents only a part, but an essential one, of the total fire protection requirements for a building. The elaborated fire protection concepts, adapted to the current OIB guidelines, were prepared by an external office.

CONCEPT UP TO 6 FLOORS

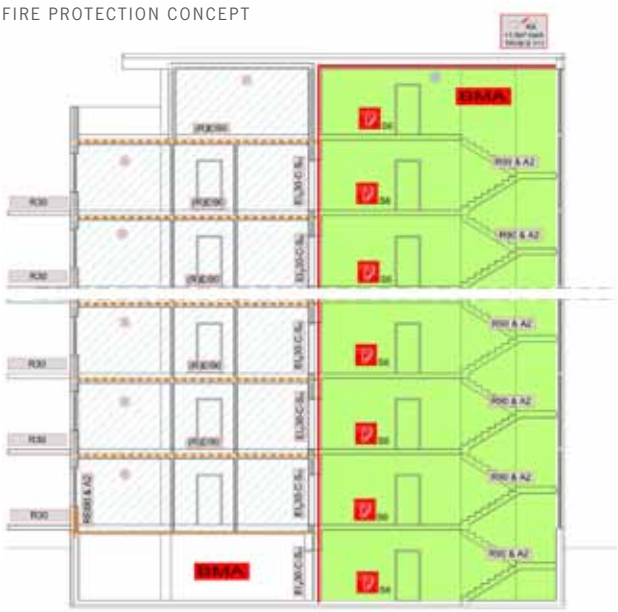
- Fire protection limit for standardized timber construction (hardly A criterion for the supporting structure)
- Visible wooden surfaces possible
- Compensation for wooden staircase considered

CONCEPT UP TO 8 FLOORS

- Maximum height before high-rise building
- Additional measures required
- Hardly combustible surfaces allowed
- Compensation measures for wood as a combustible, load-bearing material necessary

These concepts and the high-quality coverage of the calculated fire protection offer the optimal tools to provide the necessary safety standard in the event of a fire in a residential building.

FIRE PROTECTION CONCEPT

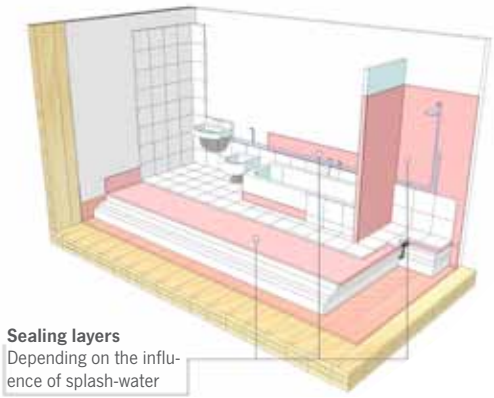


05 BUILDING SERVICES CONCEPT

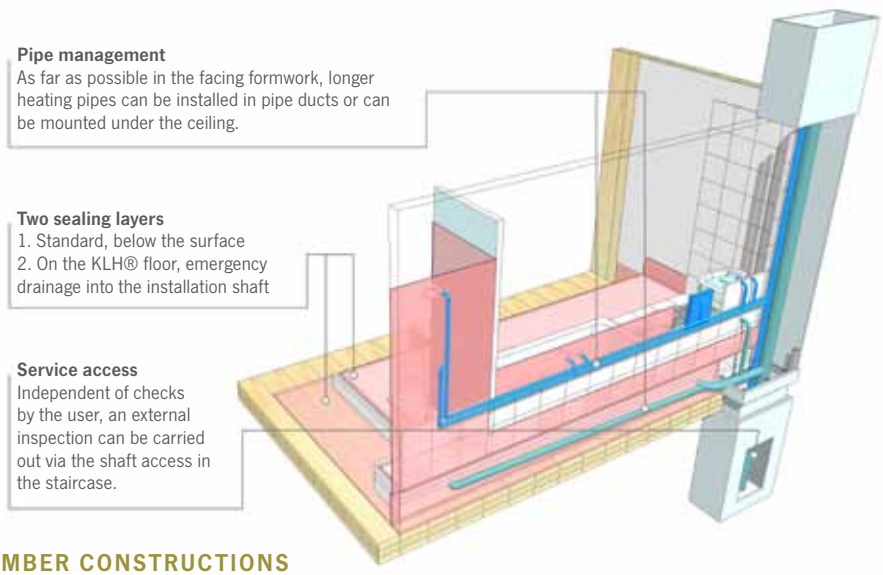
BASICS BUILDING SERVICES PLANNING

In addition to its functional activity in the subsequent operation of the building, building services planning also includes the aspect of user-friendly and economical application. The more extensive the system network, the more important it is to have comprehensible, accessible pipes. Timber construction offers a very pleasant advantage here through flexible prefabrication and assembly. However, due to the properties of wood, certain detail points must be given more attention.

SEALING LAYERS



PIPE MANAGEMENT



VARIATIONS IN TIMBER CONSTRUCTIONS

Wood can handle short-term exposure to moisture very well. The penetration depth is kept within limits and high wood moisture only becomes a negative influence over a longer period of time and at corresponding temperatures. However, since not only acute stresses, e.g. broken pipes, but also creeping failures (small leakages of the sealing layer) are to be expected, two decisive rules should be observed in timber construction:

1. POSSIBILITIES FOR INSPECTION

- Inspection openings at the critical and lowest points of the waterproof level
- Low additional planning and implementation costs, significantly increased added value for the use of the building
- Monitoring systems with humidity sensors are becoming more and more common, control via terminal device (computer, smartphone)

2. TWO SEALING LAYERS

- Sealing under the roof cladding for rafter roofs is known as an emergency roof, for flat roofs in mass timber construction the vapour barrier has established itself as a second water-bearing layer
- Due to the elevated sealing on the sides and a controllable drainage point, a second water-bearing layer can visibly drain off moisture that has penetrated unintentionally and thus protects the timber construction

In the area of wet rooms, especially rooms with water-bearing pipes in the floor, an additional sealing level with controllable drainage is recommended. In the area of wet rooms, this means a second level under the pipe routing in addition to the surface sealing against splash water.

As mass timber construction mixes (traditional) framed timber construction and the common construction methods with mineral building materials, this topic is increasingly publicised and raising awareness.

CONCEPT

In addition to the sealing levels, well-planned concepts can ensure more economic efficiency and safety.

- Central orientation of installation to the staircase
- Sufficient inspection and maintenance possibilities
- Short pipe routes
- Use facing formwork for the installation of pipes if possible
- Install heating pipes in suspended ceilings, facings or skirting boards
- Note fire protection systems which are routed on the surface

06 SOUND INSULATION CONCEPT

BASICS FOR SOUND PROTECTION IN MASS TIMBER CONSTRUCTION

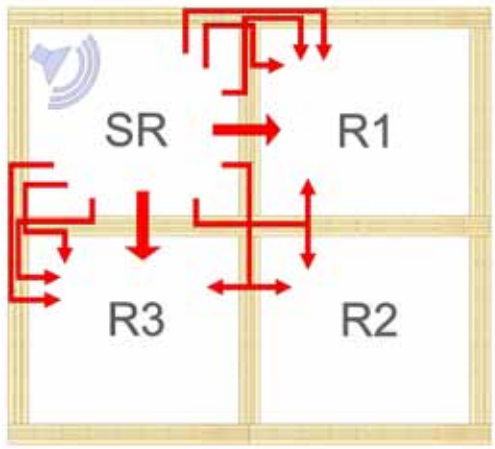
Mass timber construction offers many approaches to achieve the desired sound insulation level. The more complicated the approach, the more difficult it is to estimate the result. Compared with older construction methods, no proof-free component combinations can be taken from relevant technical literature or standards. Often project-related measurements are used for control purposes.

In the meantime, many different assembly variations with component measurements are available. Due to the variety, however, the necessary bases are often lacking in order to make a statement about the installation condition that is as accurate as possible. The joints situations play a decisive role here.

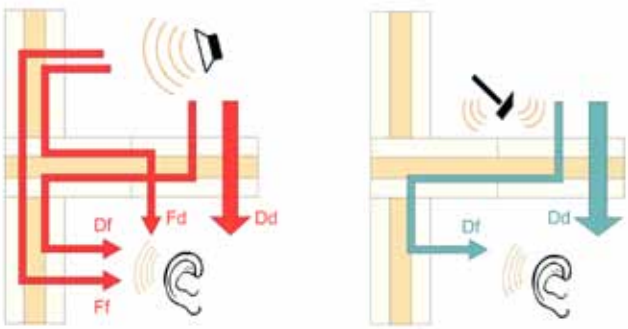
The relevant joints are typically located at the supports of ceilings, the surrounding components of flat partition walls and the transitions to general areas such as circulation areas or common rooms.

In general, three levels apply here for the estimation of the flank situation:

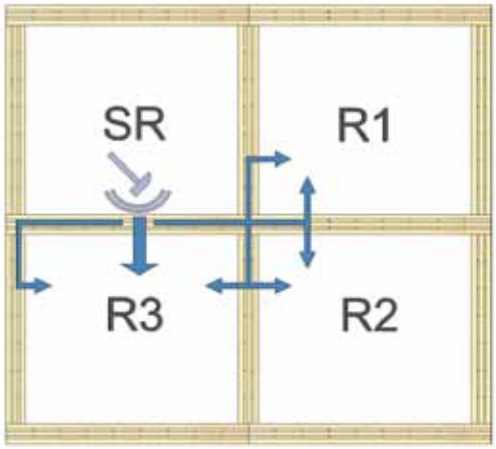
TRANSMISSION AIRBORNE SOUND



FLANKS OF A JOINT



TRANSMISSION IMPACT SOUND



S1 CONTINUOUS ELEMENT

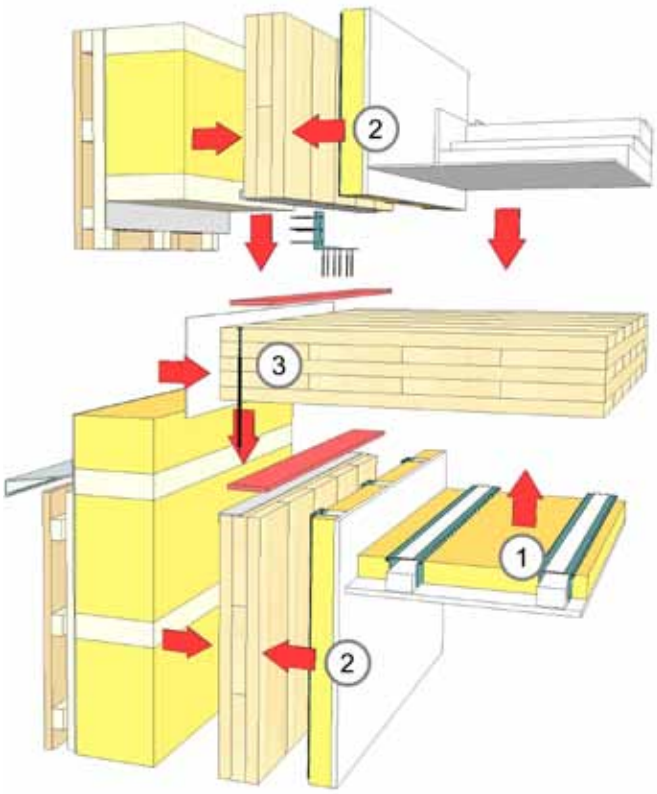
- Most unfavourable variation of flanking building component
- Depending on the sound insulation of the element and the geometry of the flank, only a relatively low flank sound insulation
- Increasing the mass, e.g. with direct ceiling weighting or covering can have a significant influence

S2 SINGLE SEPARATION

- A simple separation already brings a considerable improvement of the flank situation with it
- It is in the critical range to meet the standards for separating building components according to OIB guideline 5
- An improvement due to higher mass can be decisive here
- Elastic intermediate layer can provide the necessary decoupling
- Consider linkage from fasteners

S3 DOUBLE SEPARATION

- The flank is interrupted by two layers
- Elastic materials, adapted to the loads, are recommended
- Flank insulation value far above the required value
- Consider linkage from fasteners



With both Variation 2 and Variation 3 fasteners in the separation area bring a deterioration of the situation.

Here is the spacing and the resulting stiffness of the fastening a decisive role. Screws behave much better then solid angle connectors. Special solutions with decoupled fasteners can remedy this (if necessary).

1 **SUSPENDED CEILING**
Depending on the basic value of the floor structure, a suspension can bring the necessary improvement for the sound insulation

2 **FACING FORMWORK**
Either for the direct improvement of the build-up or for the flank-transmission necessary

3 **SEPARATION WITH ELASTIC LAYERS**
If facing formworks are to avoid, the flank-transmission can be reduced with elastic layers

SYSTEM SOLUTION

Depending on the chosen system, different approaches can be taken for the sound insulation concept. The following explanations are based on a mass timber solution.

NVQ + FACING FORMWORKS

- Simplest solution, non-visible version with facing formwork and suspended ceilings
- No special consideration for sound insulation measures (concerning structural design)
- Continuous components and more fasteners can be implemented without further measures
- The facing formworks adequately shield the joints, a favourable flank situation also for continuous building parts

DVQ / DIRECT CLADDING

- The ceiling structure is the decisive component
- The walls or ceiling can be left with a visible surface or planked directly.
- detail planning with expert advice recommended
- To touch up the sound insulation means extensive additional costs, this can be avoided by a reliable planning concept

VARIATIONS / DEVIATIONS

The combination with other components can bring significant advantages. It is important to keep an eye on the relation between costs and benefits. Frame walls, used correctly, can provide better joint separation and thus reduce flank transmission. Prefabricated floor systems, rib elements and TCC elements offer acoustic improvements through additional mass gaps directly during installation. Depending on the regional and project-specific requirements, specialist expert advice should be sought in order to find robust and economical design solutions.

DOUBLE SEPARATION FOR A SUSPENDED CEILING

© KLH®

EXAMPLE VISIBLE WALL

© Emma Cross Photographer

EXAMPLE VISIBLE CEILING

© Emma Cross Photographer

07 DETAIL PLANNING

The detailed planning shows the subtle differences of the various construction methods. Once this has been determined, this is where it is decided how much potential can be exploited through the favourable choice of details.

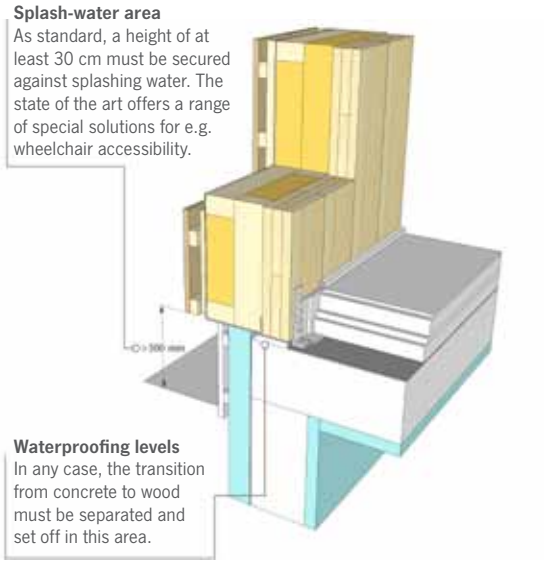
DETAILS TIMBER CONSTRUCTION

Two essential details are very important in modern mass timber construction, the plinth and the flat roof.

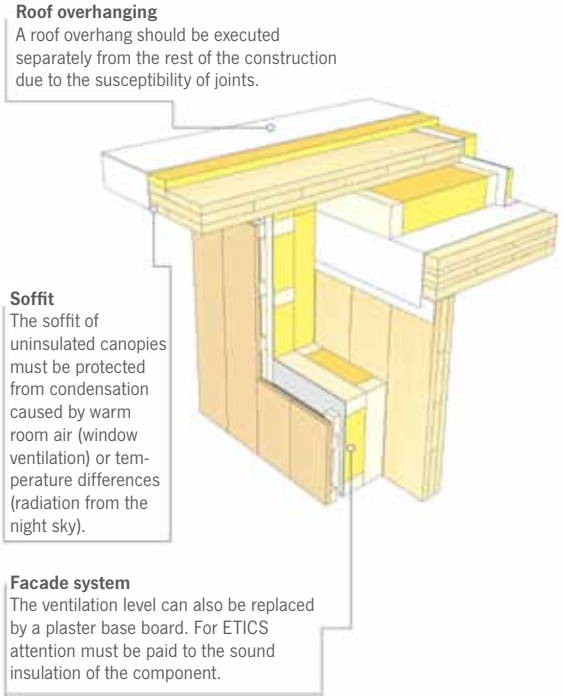
Although the plinth is already very well covered by standards and literature, this is repeatedly not or only partially implemented in practice. In addition to the standard solution of a timber building plinth shown, a very extensive range of detailed variations can already be drawn upon. The relevant standards and literature offer solutions for various level differences and the associated measures.

Even though the flat roof in solid wood construction is in general a more solid construction method than in timber frame construction, certain principles must be followed. As in building services, it makes sense to provide a second level as an emergency proofing. Some rules have become established in modern building physics and can be found in the relevant literature for flat roofs. However, the choice of proof-free constructions is limited and should be backed up by a suitable simulation / calculation in case of doubt.

STANDARD PLINTH



FLAT ROOF OVERHANGING



KLH® SYSTEM DETAILS

1 **BALCONY**
The solution for balconies are often based on the desired appearance. The example shows a suspended balcony box version.

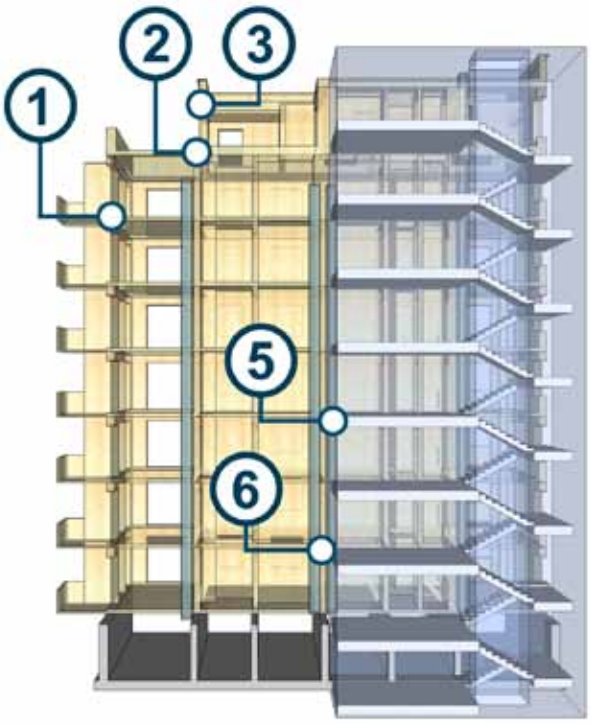
2 **TERRACE**
In addition to the flat roof requirements, terraces must also meet sound insulation requirements for units below.

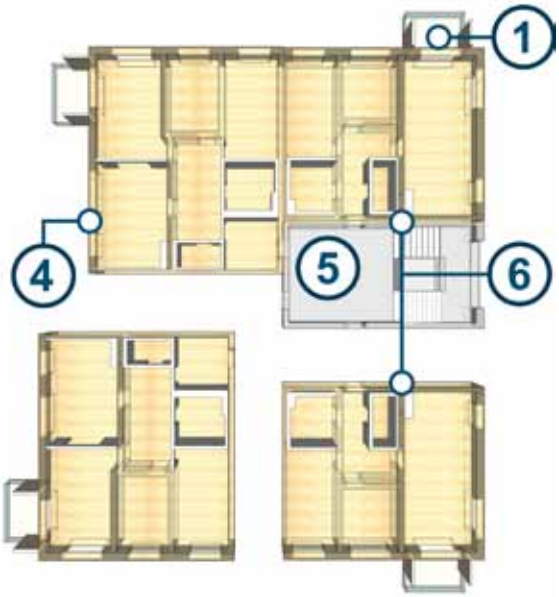
3 **ATTICA**
The attic can be carried out quickly with KLH® components. However, without the need for structural function, form blocks or wooden posts also offer a good solution.

4 **WINDOW CONNECTION**
Since overheating in summer is becoming a more sensitive issue, a version with external shading is shown here. A suitable integration into the building envelope must be provided.

5 **DOOR TRANSITION STAIRCASE**
Two separate components meet here. Since this is a decisive component, attention should be paid to the functionality of the separation.

6 **SHAFT IMPLEMENTATION**
In addition to its function as a cable routing and access point, the shaft also represents a connection between the individual floors. For this reason, both sound insulation and, in particular, fire protection must be taken into account. Various manufacturers already offer system solutions to optimise the installation.





to the details
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