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MADE FOR BUILDING
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COMPONENT CATALOGUE FOR **BUILDING A PASSIVE HOUSE**

IMPRINT

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CONTENT

PASSIVE HOUSE

More than 20 years ago, when the first residential building was constructed according to the passive house criteria in Kranichstein, Germany, the general public would not have believed that this concept would become a legally-required minimum standard in the not so distant future. Comments like "That's like living in a plastic bag!" or "The expenditure, the costs ... that'll never be worth it!" were the rule rather than the exception.

However, increasing energy costs, a shortage of raw materials and global warming caused rethinking so that previous rejections have been replaced by interested building owners looking for answers and solutions. Even politics have already reacted to this change. The information office of the European Parliament wrote on 18th May 2010 in this regard:

"The European Parliament approved the new directive for energy efficiency of houses on Tuesday. The member states must adapt their building regulations so that all buildings erected after the end of 2020 will correspond to the high energy requirements. As far as is feasible, already existing buildings must be adapted to the new requirements. For the consumer, the new directive means lower energy costs."

In plain language this means: starting from 2020, the passive house system is a legally-required reality. Reason enough to start implementing it now - considering the fact that a building has a life expectancy of 100 years, assuming a defect-free construction.

The following pages should inform the reader of the possibilities and potential of KLH solid wood panels in combination with the passive house concept. How easy it can be to adopt approved and trusted details from concrete and brick construction with the knowledge of using an ecological construction material of the highest quality.

Passive house complex "Am Mühlweg" in Vienna, Dietrich Untertrifaller Architects

AS A SUITABLE CONCLUSION TO THESE WORDS OF INTRODUCTION, LET'S HEAR FIVE EXPERT OPINIONS:

"Whoever relies on conventional construction methods in 10 years' time will be living in an outdated house, and will have been overtaken by developments." DI Othmar Hum, Swiss specialised journalist

"Whoever still builds with fossil (i.e., conventional) building techniques, will ensure a huge mortgage for the building owner, as the fossil energy prices will no longer be affordable in the foreseeable future." Hermann Scheer, holder of the Alternative Nobel Prize

"High heating costs are nothing more than a continuous repair of construction defects." Dr. Peter Tusch

"A passive house can be built cost-neutrally. The entire costs are not higher than for an average new building." (Investments over an amortisation period of 30 years) Arch. Krapmeier, Vorarlberg Energy Institute

"... a development that has now become a standard ... the so-called passive house ... which I will promote and support from my house with all possible efforts ..." Dr. Peter Ramsauer, 11th November 2009, during his inaugural speech as German Minister for Construction

01 BASIC INFORMATION

WHAT EXACTLY IS A PASSIVE HOUSE?

You could equally well ask: "What is it not?" A passive house is not a construction style that is limited to a certain construction material, but a concept for which there are many ways to achieve the goal. The final result is a new living space with minimum energy consumption and highest comfort. This shows that it is merely a consistent further development of the low-energy house as long as an active heating system can be avoided.

THE CONCEPT IS BASED ON THE FOLLOWING PILLARS:

1. Highly heat-insulated external building components
2. Construction free of thermal bridges
3. Air tightness
4. Heat recovery from the exhaust air
5. Solar heat gains

WHAT THIS MEANS FOR CENTRAL EUROPE IN PLAIN FIGURES:

1. Heating requirement ≤ 15 kWh/(m^2*a)
2. Air change rate ≤ 0.6 1/h
3. U-value of external building component ≤ 0.15 W/(m^2*K)
4. U-value window ≤ 0.8 W/(m^2*K)
5. Primary energy demand ≤ 120 kWh/(m^2*a)
6. Heating load ≤ 10 W/m^2

The term "passive house" is a designation of German origin. In Austria, this corresponds to the standard A+ or A++. In Switzerland, this construction concept is called "Minergie". However, the requirements for the building components are independent of the designation. Key factors such as thermal bridges or U-values are calculated using the ISO standard. This leads to almost equal requirements for comparable climate data.

“A passive house is a building in which thermal comfort can be guaranteed merely through the reheating of the fresh air flow that is responsible for sufficient air quality – without using additional recirculation air.”

02 EXTERNAL BUILDING COMPONENTS

GENERAL REMARKS

The maximum admissible U-value of 0.15 W/(m²*K) refers to the floor slab. Due to the different heat transmission resistances (component to air, component to ground) and thermodynamic active mechanisms, a value of 0.12 W/(m²*K) for walls and a value of 0.10 W/(m²*K) for roofs should not be exceeded.

WALL / ROOF

The construction principles approved for the KLH solid wood panels can be easily adopted. Only the insulating material thicknesses must be increased to reach the corresponding U-values. The heat transmission coefficient in structural engineering is calculated according to ISO 6946. The necessary design values are contained in EN 12524.
A building physics assessment by an expert is highly recommended. Whereas the U-value increases evenly over the thickness and the area for thermal insulation composite systems (TICS), the impact of the timber frame for the wide-spread framed construction increases with increasing insulation thickness to the averaged U-value. This is not yet referred to as thermal bridge as the “interruption” occurs regularly.

THE FOLLOWING COMPARISON SHOWS THE IMPACT OF THE WOOD PROPORTION:

TYPE	SOLID WOOD WALL WITH TICS	DOUBLE T-BEAM
Wood proportion in the insulating layer (thickness d)	0 % (d = 280 mm)	3,6 % (d = 360 mm)
Grid dimension (cm)	–	62,5
A_{Web} [W/(m*K)]	–	0,29
U-Value [W/(m²*K)]	0,12	0,12

Table 1: Comparison of TICS on KLH and double T-beams regarding the insulation thickness if a U-value of 0.12 W/(m²K) should be reached.

TICS ON KLH:

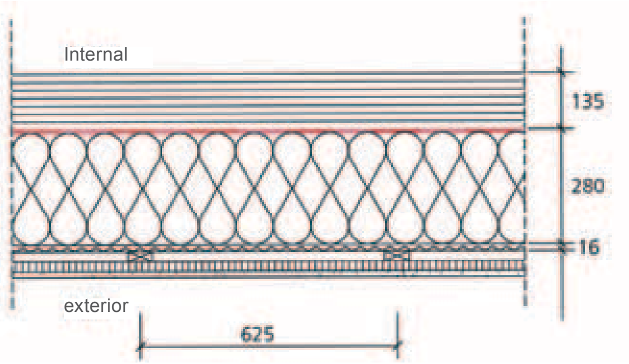


Fig. 1: TICS on KLS with jammed insulation. The mechanic fixing devices are not shown.
The insulation layer thickness is 280 mm to achieve the same U-value as in Fig. 2.

COMMON PASSIVE HOUSE WALL:

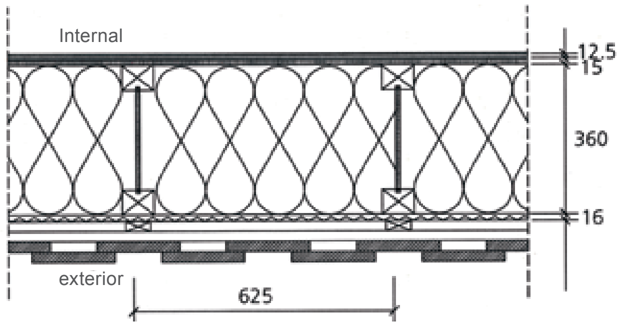


Fig. 2: Common passive house wall out of double I-joists. For a comparable insulation material this means an increase of the insulation thickness by 8 cm.

FLOOR SLAB

The floor slab can be insulated in two different ways: either on the outside by a pressure and moisture resistant perimeter insulation or on the inside by applying the insulating material on the room side.
Of course, a combination of both construction principles is also possible. Which insulation material should be preferred is the decision of the planner. Generally, the following should be remembered:

- Perimeter insulation makes a construction free of thermal bridges easier
- Internal insulation increases the risk of moisture-related construction damages at the connection of floor slab/wall

In the context of condensation aspects, the Glaser method is still in predominant use. However, this can no longer be applied when assessing “components in contact with soil”. Therefore, in cases in which the insulation is to be partially or fully arranged above the floor slab (heated side), the planner runs the risk of causing construction damages [comp. Fig. 3 and 4].

HEAT STORAGE AND KLH

To be able to assess the energy-related behaviour of a building (e.g. by the energy performance certificate), it is necessary to determine the effective heat storage capacity. This is also referred to as the energy storage mass m_W [kg].

Solar and internal heat gains are of fundamental significance for the active principle of a passive house: during winter as storage for heat (tiled stove principle) and during summer for buffering of the indoor temperature.
The utilisation factor η is a factor that reduces the entire monthly or annual gains (internal and passive-solar) to the useable share of the heat gain. The higher the m_W, the higher the utilisation factor η will be.

ACCORDING TO THE SIMPLIFIED APPROACH OF EN 832 A DIFFERENCE CAN BE MADE BETWEEN:

η = 1.00 for heavy-weight constructions
η = 0.98 for medium-heavy constructions
η = 0.90 for light-weight constructions

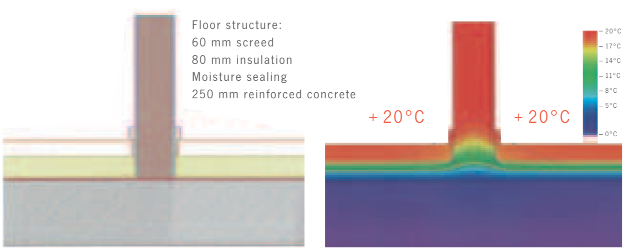


Fig. 3: Development of isotherms for a KLH wall on a concrete floor slab with internal insulation at the same time. It can be clearly recognised that the KLH panel is intersected by the 10° and 12° isotherms (mould and condensation isotherms limit).

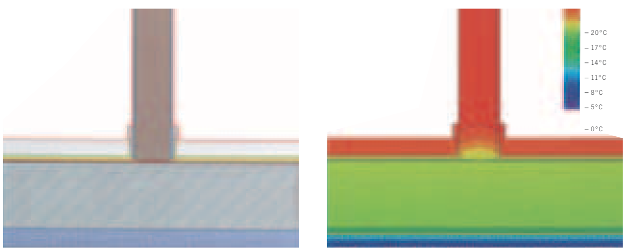


Fig. 4: Development of isotherms for a KLH wall on a concrete floor slab with external insulation at the same time. It can be clearly recognised that the KLH panel is no longer intersected by the 10° and 12° isotherms (mould and condensation isotherms limit).

THE FOLLOWING CAN BE CLASSIFIED AS LIGHT-WEIGHT BUILDING STRUCTURES:

- Buildings in timber construction without solid internal construction material
- Buildings with suspended ceilings and mainly light dividing walls
- Light timber constructions with any type of screeds

THE FOLLOWING CAN BE CLASSIFIED AS MEDIUM-HEAVY STRUCTURES:

- Buildings with mainly solid external and internal construction material, floating screed and without suspended ceilings
- Brick and reinforced concrete buildings
- Solid timber construction (full-size laminated timber or timber slab constructions) with and without screed, provided that no suspended ceilings or hollow or heat-insulated wall attachments have been used

THE FOLLOWING CAN BE CLASSIFIED AS HEAVY-WEIGHT STRUCTURES:

- Buildings with very solid external and internal construction material (old buildings)

Regarding heat storage capacity, KLH can be compared with brick or reinforced concrete buildings and it uses the solar and internal heat gains better than the timber frame construction.
The heat capacity of the internal construction layers facing the internal rooms has a significant impact on the temperature stability and on comfort during summer – of special importance are those on the internal walls and suspended ceilings.
(from: www.passipedia.de)

PASSIVE HOUSE AND PHASE SHIFTING

The temperature-amplitude ratio (TAR) of the opaque external construction materials is of no importance for the insulation standard of the passive house – neither for the annual heating requirement nor for comfort during summer.

The reason for this is that highly heat-insulated components already cause such a strong reduction of the amplitudes, independent of the time period, that the additional dynamic damping effects are no longer relevant. In case of badly (worse) insulated components, however, the impact of the TAR becomes visible.
(from: www.passipedia.passiv.de)

03 FREE OF THERMAL BRIDGES

GENERAL REMARKS

According to their definition, thermal bridges are areas in a building shell with significantly higher heat transmission. Irregularities in the normally undisturbed external component parts are determined by the averaged U-value and do not require further consideration. These lead to higher energy consumption and possibly even to mould on the inside of the components.

Due to the increasing thickness of insulation materials, elements such as the connection joints of two components become more and more important. According to experiences in passive house construction, the avoidance of thermal bridges is one of the most efficient technical methods to improve energy efficiency.

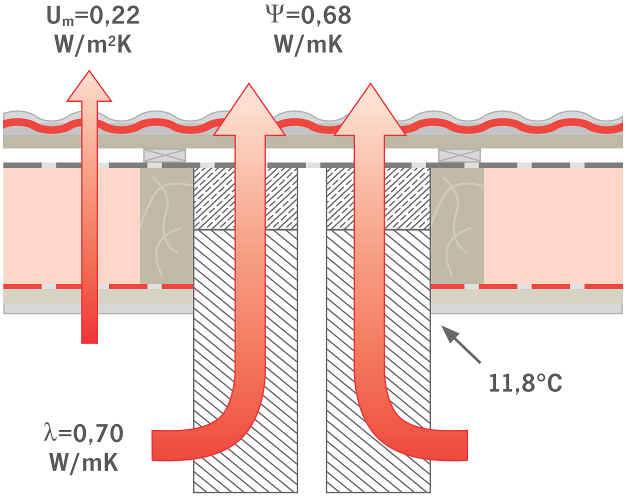


Fig. 5: The same amount of heat is lost per metre of a thermal bridge at the top of the masonry as on three square metres of undisturbed roof area. Weaknesses in the roof area can be easily visually identified in this image from the melted snow.

Normal heat loss by area is determined using the averaged U-value of the component, multiplied by a temperature difference between the inside and outside and the entire surface (outside dimensions) of the component.

Heat loss due to irregularities in the component (component joints or isolated penetrations) will be shown with the coefficient Ψ_a [W/(m*K)] (linear thermal bridges) or χ [W/K] (isolated thermal bridges). Multiplied by the existing running metre of the edge or the amount of isolated thermal bridges, the additional heat loss through the thermal bridges can be calculated.

The total heat loss results from the sum of the normal heat loss and the loss through the existing thermal bridges.

Geometric thermal bridges normally do not cause problems. They appear when external components with different orientations touch each other and therefore the external dimensions are different to the internal dimensions – e.g. at the house edge, eaves connection, on the verge or on the roof ridge.

By contrast, figure 6 shows a structural penetration that will require an energy-related calculation if it cannot be avoided by structural measures. By a stringent separation of the static bearing structure and the insulation layer, structural thermal bridges can be easily avoided.

Fig. 6: A linear thermal bridge in formation. If the steel beam is not additionally integrated into the insulation, condensation is to be expected.

Figure 7 shows the planning principle from the plotter pen. For this purpose, scale drawings from the building shell are used. For a passive house, a plotter pen is used the width of which corresponds to a heat transmission resistance of R = 6 m²K/W. For an insulation material of thermal conductivity group 0.04 W/(mK), this means a scale width of 24 cm.

If the application on the outside of the building in the full width of the insulation material is successful, one can be sure that the tested details will comply with the criteria for structures free of thermal bridges.

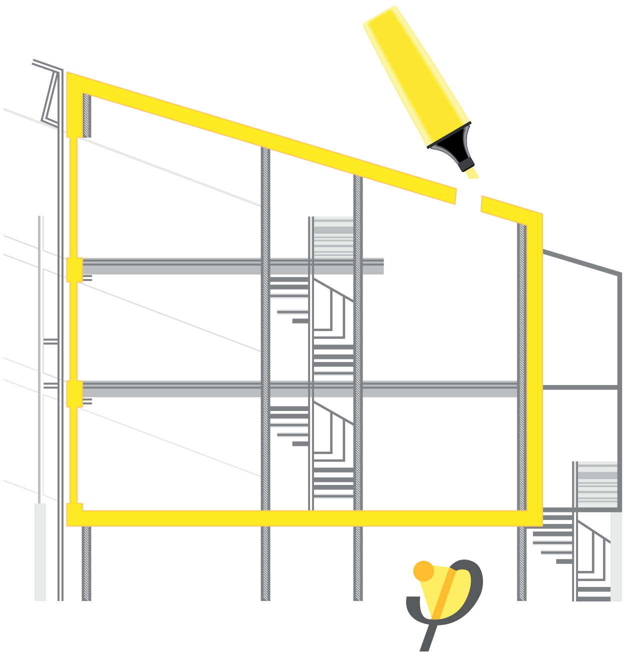


Fig. 7: Planning principle from the "plotter pen". [www.passiv.de]

STRUCTURAL THERMAL BRIDGES MUST NOT EXCEED A VALUE OF

$\Psi_a = 0{,}01$ W/(m*K)

If a more favourable selection of structural details is successful in having no thermal bridge loss coefficient exceed this value, the sum will be negligibly reduced against the normal heat loss of the component surfaces and the construction will be free of thermal bridges. The index "a" stands for external dimension reference and is generally used.
In contrast, "i" stands for the internal dimension reference but has no longer any significance in practice.

ISOLATED THERMAL BRIDGES

Isolated thermal bridges, as they might also arise due to the joining means, are dealt with in the ISO 6946 "Building components – Thermal resistance and thermal transmittance coefficient – Calculation methods", Annex D. In this context, the detailed calculation according to ISO 10211 "Thermal bridges in buildings – Thermal flows and surface temperatures – Detailed calculation" (3D simulation) or the simplified method for the consideration of joining means, described in Annex D, can be used.

If the entire correction according to Annex D of ÖNORM EN ISO 6946 is less than 3% of U, the isolated thermal bridges do not need to be taken into consideration.

The implementation of thermal bridge-free or significantly reduced constructions with KLH solid wood panels is exceptionally easy. The systematic separation of the support layer and the insulating layer makes the development of a passive house with KLH a piece of cake.

04 AIR TIGHTNESS

GENERAL REMARKS

The air change rate, short n_{50}-value, is an indicator for the tightness of a building. The n50-value is determined using a ventilator that is installed in the opening of a building and through a pressure of +/- 50 Pascal. Through the orifice width in front of the ventilator and the number of revolutions of the fan, the transported air amount in [m^3/h] (average value from the +/- pressure measurement) will be determined and divided by the air volume of the building. The result is the leakage rate in [1/h].

Air tightness is not a luxury but a necessity. The often-used argument – even from experts of the trade – according to which "a bit of leakiness is not harmful" damages the entire construction industry.

Ventilation over joints, regardless of whether they are purpose-built in the building or (wilfully) integrated into the window frames, is not possible; high energy losses and moisture-related construction damages through condensation, on the other hand, are possible.

THE ADVANTAGES OF AIRTIGHT BUILDING SHELLS ARE:

- Avoidance of moisture-related construction damages
- Avoidance of draught and cold feet
- Avoidance of high infiltration heat losses
- Basis for the use of controllable, demand-driven ventilation
- Basis for functional heat insulation
- Improvement of sound insulation
- Improved indoor air quality

It is only favourable if the support component itself is already tight enough. 5s-panels from KLH or 3s-panels in combination with e.g. films make it easier for the user to significantly exceed the minimum values for the air tightness. For the joint area, pre-fabricated films, strips of cardboard and adhesive tapes are available.

IN TIMES OF LEAKING WINDOWS, DOORS AND STOVE HEATING THE FOLLOWING PRINCIPLE APPLIED:

„A further reason to strictly adhere to fresh air in the residential areas comes from our experience that bad air is the source of many chronic conditions and that it clearly plays a big role in publicly spread diseases such as scrofula and tuberculosis. Hence, in cases in which the natural ventilation is not sufficient to prevent the increase of the amount of carbon dioxide of the air in our living space and bedrooms by 1 per mil, artificial ventilation should be used.“

(M. v. PETTENKOFER 1858)

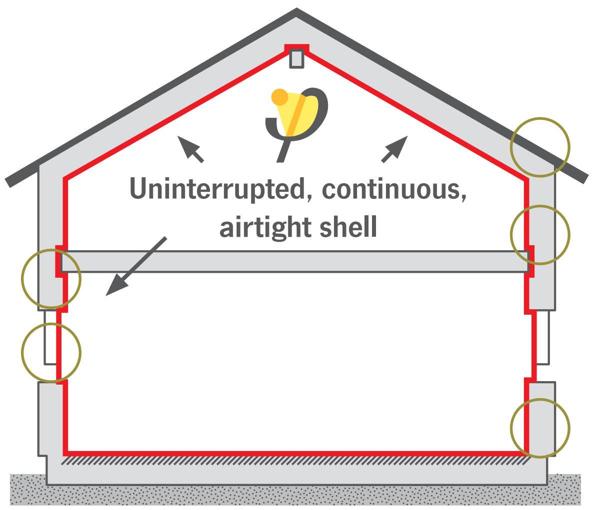


Fig. 8: The airtight shell must be planned in advance in all other aspects. Systems of different providers should not be combined. [www.passiv.de]

PLANNING PRINCIPLE

The airtight layer surrounds the building without interruptions. There is only one tightness layer that can be interrupted for planned openings, e.g. for ventilation.

Whoever builds in solid construction with KLH has the advantage of a stringent separation of the three functional layers “supporting structure, seal, insulation”. On the other hand, whoever builds in solid construction with fossil materials, e.g. bricks, has a mixture of the functional layers and, hence, additional sources of errors. For installation of brick walls, the interior plastering necessary as a sealing layer is continuously interrupted. These weaknesses then need to be removed with a great deal of effort.


Blower-Door Messprotokoll

Minneapolis Blower Door Modell 3

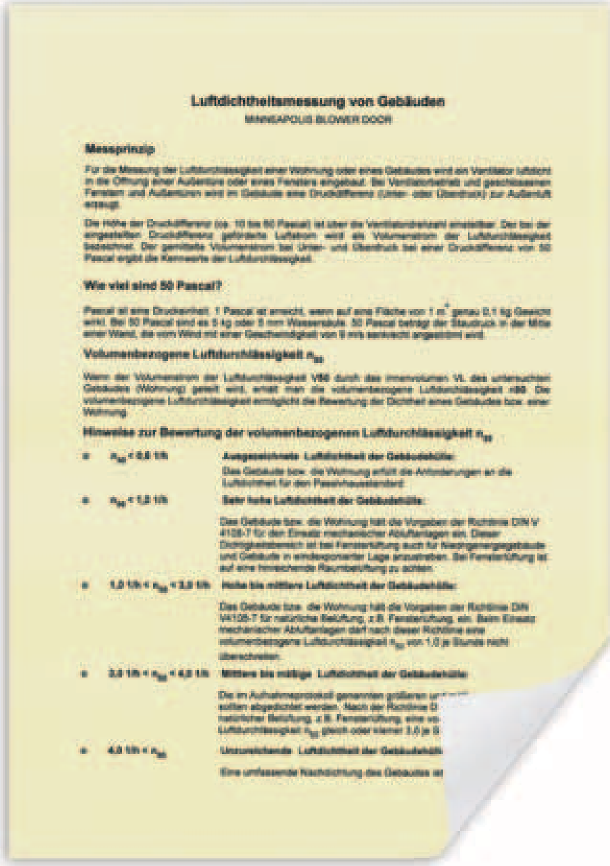
Messdaten

Unterdruck

Überdruck

Ergebnis, Kenngrößen :

	n_{50}
Unterdruck	0,12
Überdruck	0,18
Mittelwert	0,15
Grenzwert	0,6


Luftdichtheitsmessung von Gebäuden

MINNEAPOLIS BLOWER DOOR

Messprinzip

Wie viel sind 50 Pascal?

Volumenbezogene Luftdurchlässigkeit n_{50}

Hinweise zur Bewertung der volumenbezogenen Luftdurchlässigkeit n_{50}


Zertifikat

Fig. 9: A Blower Door Test in a passive house built with KLH solid wood panels. Through the support of an excellent air tightness concept, an n_{50}-value of 0,15 h^{-1} could be realised [with the kind support of Eberle • d e n k f a b r i k • Dornbirn, Austria].

PENETRATIONS

The main objective should always be to avoid penetrations of the building shell or airtight layer, or at least reduce these penetrations to a minimum.

Isolated penetrations with power cables, piping or supply lines can never be fully avoided. However, and as shown on the images, these openings should be implemented and sealed correspondingly.

It is important that the details are planned. This also includes the building materials being adjusted to each other so as to ensure tightness over a usage period of decades.

Through the systematic separation of support, seal and insulation layer in a construction with KLH solid wood panels, these connections can be implemented easily and permanently.

Fig. 11: If the penetrations cannot be avoided, suitable and approved systems should be used for sealing. A quick and permanently tight mounting will justify the additional costs [with the kind support of the company pro clima 2011].

Fig. 10: If the penetrations cannot be avoided, suitable and approved systems should be used for sealing. A quick and permanently tight mounting will justify the additional costs [with the kind support of the company pro clima 2011].

05 HEAT RECOVERY

HEAT RECOVERY FROM THE EXHAUST AIR

Heat recovery from the exhaust air is indispensable to guarantee the low heating requirement of a passive house. If the used air were only discharged to the outside, the demand for heating energy could not be lowered to less than 30 kWh/(m²a).

Window ventilation, still a common method, is no longer state of the art to supply sufficient air quality. In areas with high noise pollution (e.g. airport or street traffic), everyone is aware of the disadvantages of such technology.

In winter at the latest, however, everybody knows what it means to wake up relaxed due to a sufficient supply of oxygen. What is a common feature in terms of ventilation and air-conditioning in cars is still rather an exception to the rule in buildings.
However, when comparing the amount of time people spend in buildings and in vehicles, the question arises: Why should a house be less intelligent than a car?

The low air change rates that can be easily achieved in the KLH construction method enable an economic operation of ventilation and heating systems.

WHEN INSTALLING A HEAT RECOVERY VENTILATION SYSTEM, TWO FACTORS MUST BE TAKEN INTO CONSIDERATION:

- Use round pipe diameters with smooth internal walls for easier cleaning of the pipes.
- Remoistening of the supplied air through water spray on the injection openings. This ensures a proper hygiene in the pipe system.

The last point in particular – when not implemented – leads to impairments for users and the building. People feel uncomfortable during the heating period as the room air is becoming too dry and even the KLH panel reacts with an increased shrinking.
Due to the compact construction, ventilation devices can be easily attached to the wall and hidden behind instal-

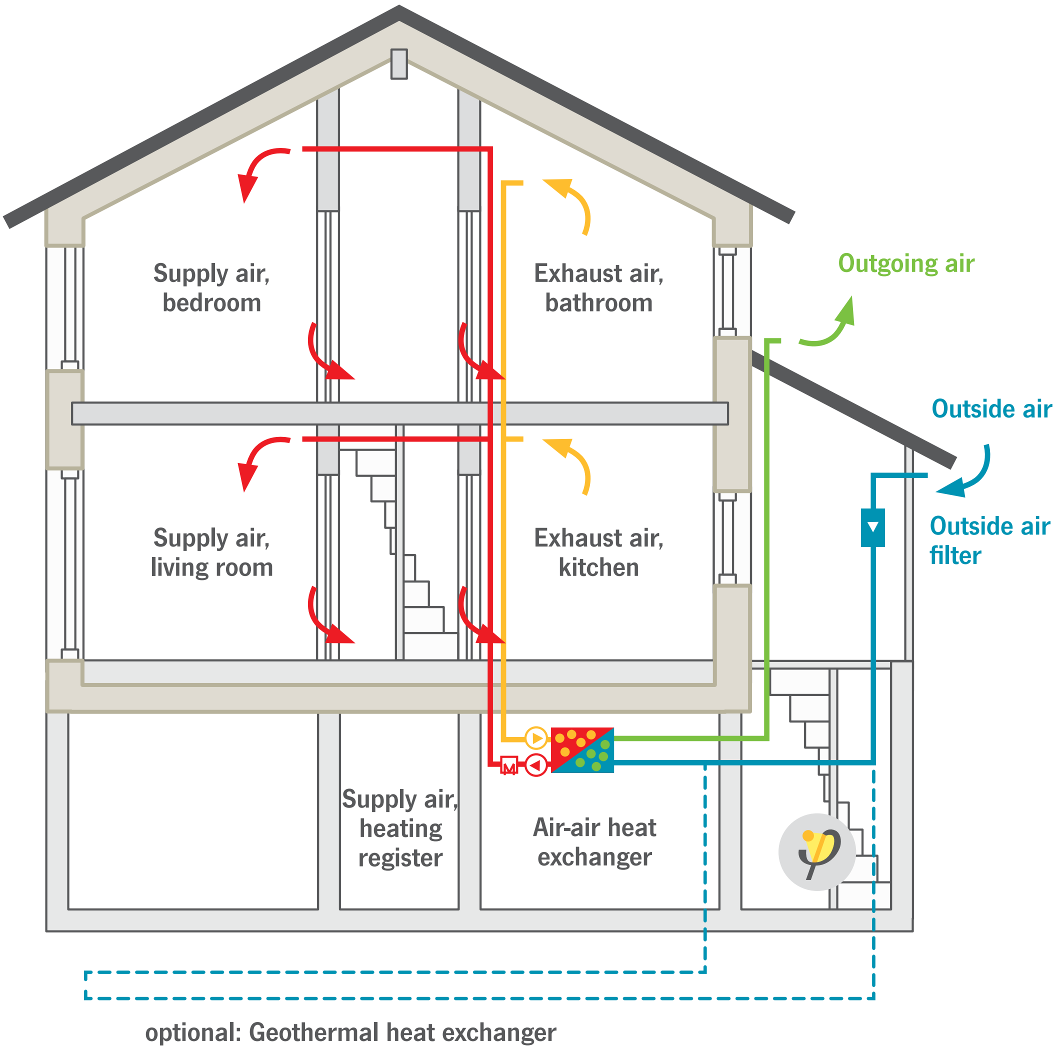


Fig. 12: Today, modern ventilation technology is capable of recovering 8 to 15 times the energy from exhaust air that is necessary for its operation.

lation layers. KLH solid wood panels are perfectly suited for this purpose and can easily absorb the additional "load". The supply and exhaust pipes have an outer diameter of 60 mm and are therefore narrow enough to be laid without problems.

THE SUPPLY AND EXHAUST OPENINGS CAN BE LOCATED

- underneath a suspended ceiling
- behind a wall attachment
- within the floor construction.

Most of the time, the planner has more than one option to plan the routing of the pipes to be as space-saving as possible.

Fig. 13: Mounting of a ventilation system on a KLH wall [with the kind support of Eberle • d e n k f a b r i k • Dornbirn, Austria].

Fig. 14: Running of pipes behind suspended ceiling. System HOVAL [with the kind support of Eberle • d e n k f a b r i k • Dornbirn, Austria].

HEATING SYSTEM

According to the definition of a passive house, the heating load is so low (≤ 10 W/m²) that the missing heat quantity can be provided through an after-heating of the supply air, which is necessary in any case for room-hygienic reasons. In general, a passive house would also function without an active heating system and this additionally increases the efficiency.

In practice, however, passive houses without an active heating system have not been widely adopted. This is due to the following reasons, among others:

- The heating requirement calculations do not take individual consumer behaviour or personal preferences into consideration
- Geographical circumstances (shadowing, vegetation, neighbouring buildings or similar) can only be considered in part or not at all

Radiant panel heating systems in floors or walls have proved successful in practical application. Due to the low temperature difference between flow and return, as well as the very low inlet temperature in general, operating these systems can be extremely energy-efficient. Suitable compact devices with heat pump technology, partly already integrated into the ventilating system, have proved successful and at the same time serve the domestic hot water supply reliably and regardless of weather conditions.

Fig. 15: Piping of an underfloor heating [with the kind support of Eberle • d e n k f a b r i k • Dornbirn, Austria].

VENTILATION, HEATING, HOT WATER

A VENTILATION SYSTEM IS GENERALLY DIVIDED INTO THREE PARTS:

1. Outer piping
2. Ventilation - heating - hot water
3. Inner piping

Here is a fact which might be surprising for the reader: ventilation, heating and hot water together in one category has been state of the art since 1997 and is no longer fiction. Easy breathing, comfortably warm rooms and unlimited bathing fun – all with one device which is no larger than a fridge.

The pipes for the supply and exhaust air can be laid in the ceiling or the floor depending on the planning. Due to the pressed cross section and the generally available floor construction heights made of fill and impact sound insulation, normally there is sufficient available space.

Openings can be pre-fabricated in the works against a slight expenditure in case of pre-planning. If now even the supply lines for hot domestic water will be combined and optimised in the supply lines, nothing will get in the way of a laying in the floor, as there are no more heating pipes.

A short summary indicates what owners of passive houses will have to live without and what their benefits are.

A PASSIVE HOUSE DOES WITHOUT:

- Gas and oil tanks
- Connection to the public gas grid
- Chimney
- Radiators
- Heating bills
- Technical room for burner and hot water tank
- Construction damages due to moisture in rooms

A PASSIVE HOUSE BENEFITS FROM:

- Space to live
- Comfort
- Certainty about following the right path

06 HEAT GAINS

GENERAL

The solar heat gains due to the radiation transmission of transparent components will be determined according to EN 832.

THEY ARE DEPENDENT ON:

- Orientation (azimuth and inclination) of the transparent components
- Prevention of the solar radiation through shadowing (topographic or structural obstacles, plants, etc.)
- Total energy transmittance of the glazing
- Solar heat gains through conservatories
- Heat gains through transparent heat insulations

The window assumes a special position among the components in a passive house. It is one of the most important pillars of a passive house.

Whereas in the past it was a weakness in the building shell required for lighting, thanks to modern technology, it has become an indispensable functional unit.

A short summary about the development of the window in the past 40 years and the resulting reduction in heating costs and the increase in comfort:

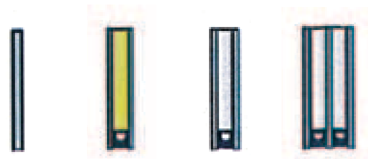
GLAZING	1-WINDOW PANE	2-INSU-LATION	2-HEAT PRO-TECTION	3-HEAT PRO-TECTION
				
U_g-value [W/(m^2*K)]	5.60	2.80	1.20	0.65
Surface temp. in °C	–1.8	9.1	15.3	17.5
g-value	0.92	0.80	0.62	0.48

Table 2: Development of glazing in the past 40 years.
Tenfold increase in efficiency. [www.passiv.de]

The development has resulted in ever better glazings: from single glazing (far left) to glazing suitable for passive houses (far right). Only these windows have a warm inside surface when the weather outside is freezing.

Lower energy loss and better comfort go hand in hand. Triple glazing, coatings with a low emissivity and an optimised frame also lead to the fact that these windows not only lose no more heat but can even produce heat.

Below you will find only a few examples of how the frame and pane can be implemented. All passive house windows have compliance with the stringent requirements of U-windows ≤ 0.8 W/(m²*K) in common.

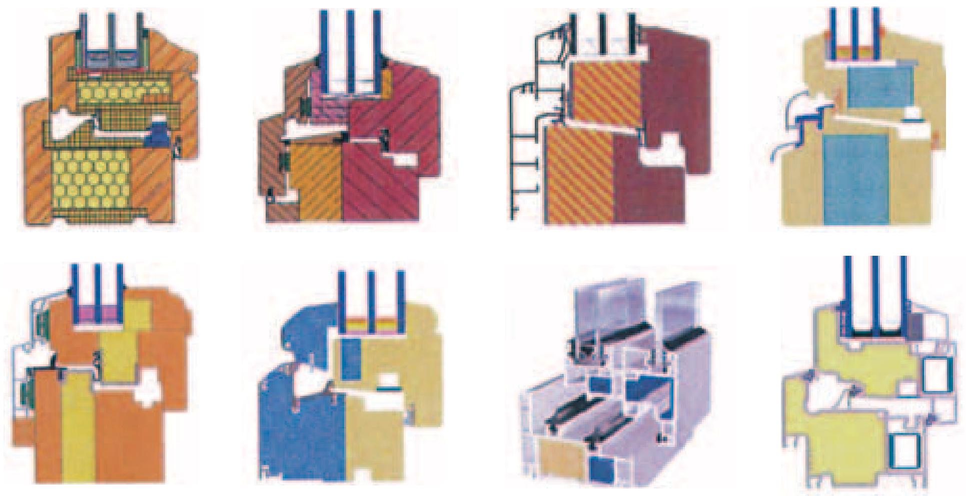


Fig. 16: Similar to glazing, the development of the window frames has also made a massive step in the direction of energy efficiency.
Fig. 16 shows an overview of the variety of constructions. [www-passiv.de]


Architect: Bembé Felix & Sebastian Dellinger, Dirk Wilhelmy

These window frames share another common characteristic: they can be easily mounted to the KLH solid wood panels.

MOUNTING WITH E.G. ALUMINIUM BRACKETS OFFERS SEVERAL ADVANTAGES:

- Reliable load bearing
- Free positioning of the window in insulating layer
- Without thermal bridges
- Quick and easy connection to the KLH solid wood panel
- By using a slightly larger window frame for the precise opening in the KLH panel, the sound insulation of the installation situation is improved as joints between the wall and the window will be prevented

If you want to further improve the window frame, you can place insulation material on top of it. The resulting larger shadowing of the glass area can be reduced by slanting the insulation in the reveal area.

For composite timber-aluminium components, it is important that the aluminium cover is adjusted to the reach over the insulation of the frame. If the aluminium cover is installed onto the additionally insulated area, the very high thermal conductivity of the aluminium will cause a clear worsening of the installed thermal bridge. Therefore, it is recommended to only install the aluminium cover until shortly behind the plaster edge. Whether such an adaptation of the window construction is feasible must be coordinated with the manufacturer of the window.

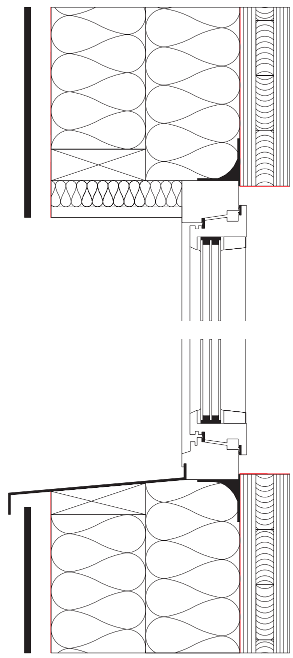
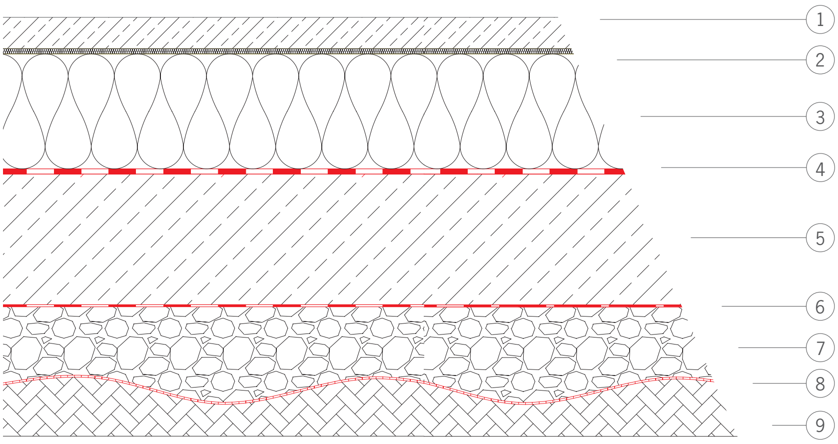


Fig. 17: Vertical section – window abutment with mounting bracket

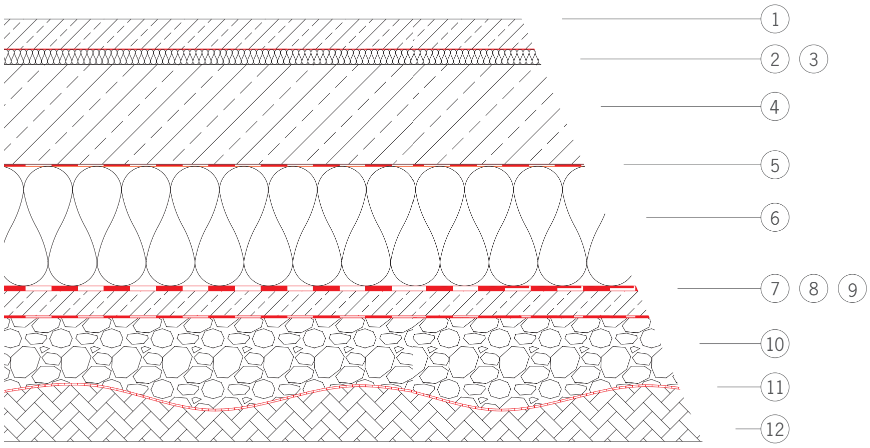
07 COMPONENTS

7.1 FLOOR SLABS



7.1.1 FLOOR SLAB WITH INSULATED UPPER SIDE

	CONSTRUCTION MATERIALS	s	ρ		μ	s_d	c	s'	λ	U_m-value
		[cm]	[kg/m³]	[kg/m²]	[-]	[m]	[J/(kg*K)]	[MN/m³]	[W/(m*K)]	[W/(m²*K)]
1	Cement screed	5	2.000	100	50	2,5	1.000	...	1,400	0,15
2	PE soft foam, seal joints	1	34	0,34	500	5	900	...	0,040	
3	EPS	22	20	4,4	30	6,6	1.500	...	0,040	
4	Bitumen-aluminium layer	0,4	...	5,2	...	1500	1.260	...	0,170	
5	Reinforced concrete	25	2.400	600	100	25	1.120	...	2,500	
6	Construction paper	...	...	0,1	...	...	...	...	0,170	
7	Drainage layer	15	1.800	270	2	0,3	1.000	...	0,700	
8	Filter fabric	...	...	0,14	1.000	...	1.000	...	0,500	
9	Soil	...	...	...	...	...	...	...	...	



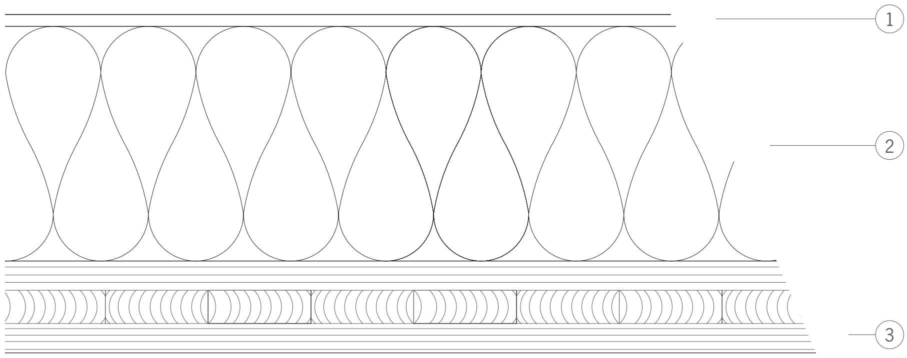
7.1.2 FLOOR SLAB WITH INSULATED UNDERSIDE

	CONSTRUCTION MATERIALS	s [cm]	ρ [kg/m³]	[kg/m²]	μ [-]	s_d [m]	c [J/(kg*K)]	s' [MN/m³]	λ [W/(m*K)]	U_m-value [W/(m²*K)]
1	Cement screed	5	2000	100	50	2,5	1.000	...	1,400	0,15
2	PE film, overlapping joints	0,02	...	0,2	100.000	20	790	...	0,230	
3	Mineral wool – impact sound insulation	3	...	2,7	1	0,03	1.030	10	0,035	
4	Reinforced concrete	20	2400	480	100	20	1.120	...	2,500	
5	PE film (2-layer)	0,04	...	0,4	100.000	40	790	...	0,230	
6	Foam glass in polymer bitumen	24	105	25,2	1.000.000	240.000	1.000	...	0,045	
7	Polymer bitumen (2-layer)	0,8	1050	8,4	40.500	324	1.260	...	0,170	
8	Lean concrete / granular subbase	5	2000	100	100	5	1.080	...	1,200	
9	Construction paper	...	...	0,1	...	...	...	...	0,170	
10	Drainage layer	15	1800	270	2	0,3	1.000	...	0,700	
11	Filter fabric	...	...	0,14	1.000	...	1.000	...	0,500	
12	Soil	...	...	...	...	...	...	...	...	

7.2 EXTERNAL WALL – TYPES WITH KLH

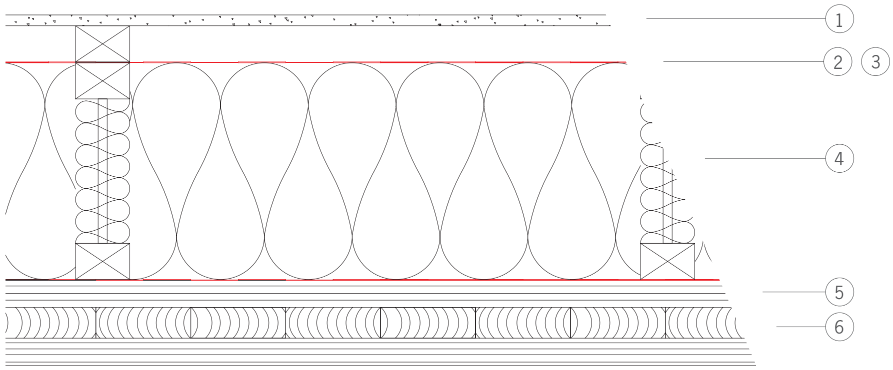
To be able to better compare different building structures, a thermal conductivity group of 040 was assumed for all insulation material types. Of course, by now, there are products that do not achieve this value, but generally this is only at the third place after the decimal point of the lambda value. Furthermore, additional layers on the room side have been omitted as otherwise the variety of possible combinations would blow the scope of this list.

In individual cases, however, it might be necessary to use internal insulation for an installation or to improve fire protection or noise control.



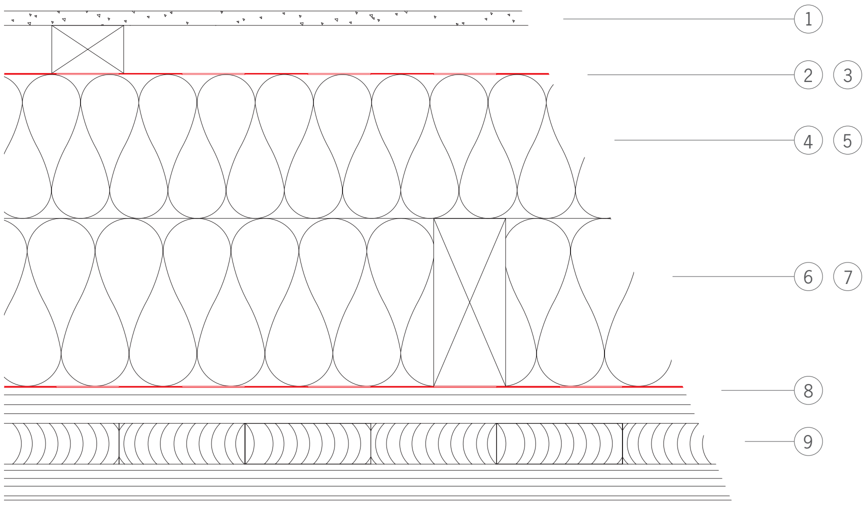
7.2.1 NOT BACK VENTILATED FACADES – KLH AND TICS (THERMAL INSULATION COMPOSITE SYSTEM)

	CONSTRUCTION MATERIALS	s	ρ		μ	s_d	c	s'	λ	U_m-value
		[cm]	[kg/m³]	[kg/m²]	[-]	[m]	[J/(kg*K)]	[MN/m³]	[W/(m*K)]	[W/(m²*K)]
1	Plastering system	0,7	1.200	8	15	0,075	1.120	...	2,000	
2	Insulation (EPS-F)	30	12	3,60	1	0,3	1.450	...	0,040	0,12
3	KLH panel (WSI or 5-layer)	9,4	500	47	25/50	...	1.600	...	0,130	



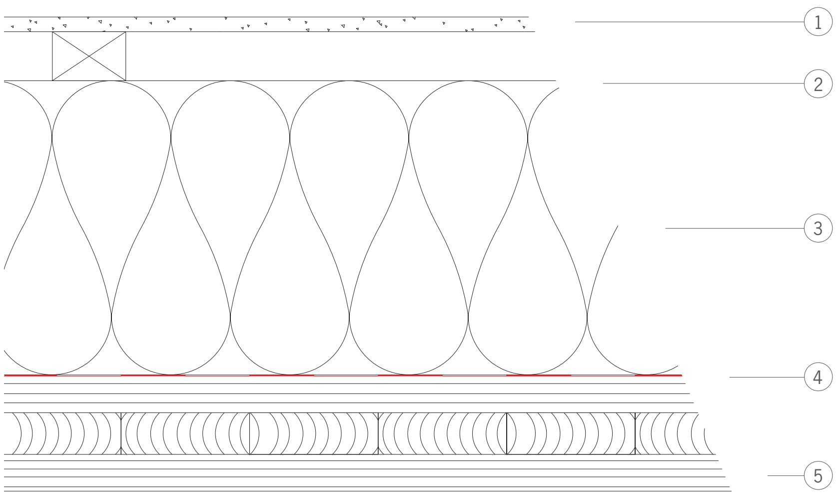
7.2.2 BACK VENTILATED FACADES – I-JOISTS ON KLH

CONSTRUCTION MATERIALS	s [cm]	ρ [kg/m³]	[kg/m²]	μ [-]	s_d [m]	c [J/(kg*K)]	s' [MN/m³]	λ [W/(m*K)]	U_m-value [W/(m²*K)]
1 Facade	...	...	...	...	...	...	...	...	0,12
2 Back ventilated air layer, vertical	4	...	...	...	...	...	...	...	
3 Wind proofing	0,05	...	0,5	22	0,01	1.000	...	0,170	
4 Insulation between webs	33	35	...	1	0,33	910	...	0,040	
5 Airtight layer	0,01	...	0,40	100.000	10	790	...	0,500	
6 KLH panel	9,4	500	47	25/50	...	1.600	...	0,130	



7.2.3 BACK VENTILATED FACADES – CROSS-LAMINATED TIMBERS ON KLH

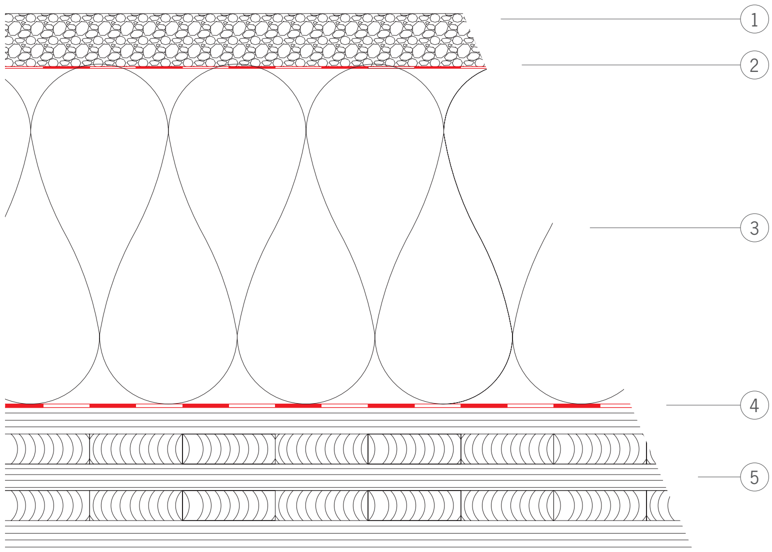
	CONSTRUCTION MATERIALS	s [cm]	ρ [kg/m³]	[kg/m²]	μ [-]	s_d [m]	c [J/(kg*K)]	s' [MN/m³]	λ [W/(m*K)]	U_m-value [W/(m²*K)]
1	Facade	...	...	...	...	...	...	...	...	
2	Back ventilated air layer, vertical	4	...	...	...	...	...	...	...	
3	Wind proofing	0,05	...	0,5	22	0,01	1.000	...	0,170	
4	Nogging piece 6x18, grid 0.625 m (vertical)	18	500	8,6	...	...	1.600	...	0,130	
5	Insulation between nogging pieces	18	35	5,7	1	0,18	910	...	0,040	0,12
6	Nogging piece 6x16, grid 1.25 m (vertical)	16	500	3,8	...	...	1.600	...	0,130	
7	Insulation between nogging pieces	16	35	5,3	1	0,16	910	...	0,040	
8	Airtight layer	0,01	...	0,40	100.000	10	790	...	0,500	
9	KLH panel	9,4	500	47	25/50	...	1.600	...	0,130	



7.2.4 BACK VENTILATED FACADE – JAMMED INSULATION ON KLH

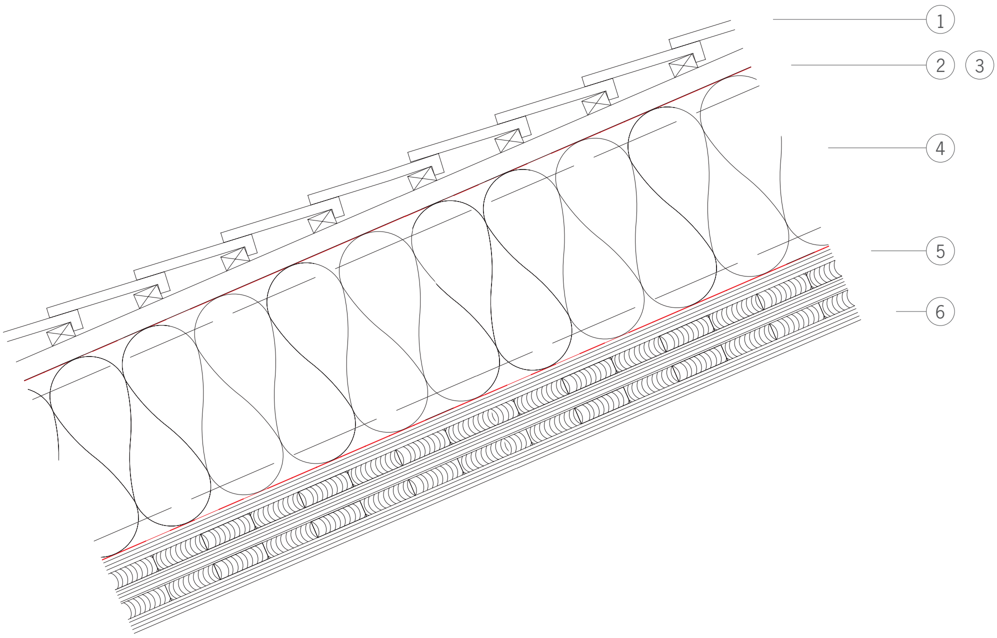
	CONSTRUCTION MATERIALS	s [cm]	ρ [kg/m³]	[kg/m²]	μ [-]	s_d [m]	c [J/(kg*K)]	s' [MN/m³]	λ [W/(m*K)]	U_m-value [W/(m²*K)]
1	Facade	...	...	...	...	...	...	...	...	0,12
2	Back ventilated air layer, vertical	4	...	...	...	...	...	...	...	
3	Insulation, pressure-resistant, windtight	30	160	48	1	0,30	1.030	...	0,040	
4	Airtight layer	0,01	...	0,40	100.000	10	790	...	0,500	
5	KLH panel	9,4	500	47	25/50	...	1.600	...	0,130	

7.3 ROOF WITH KLH



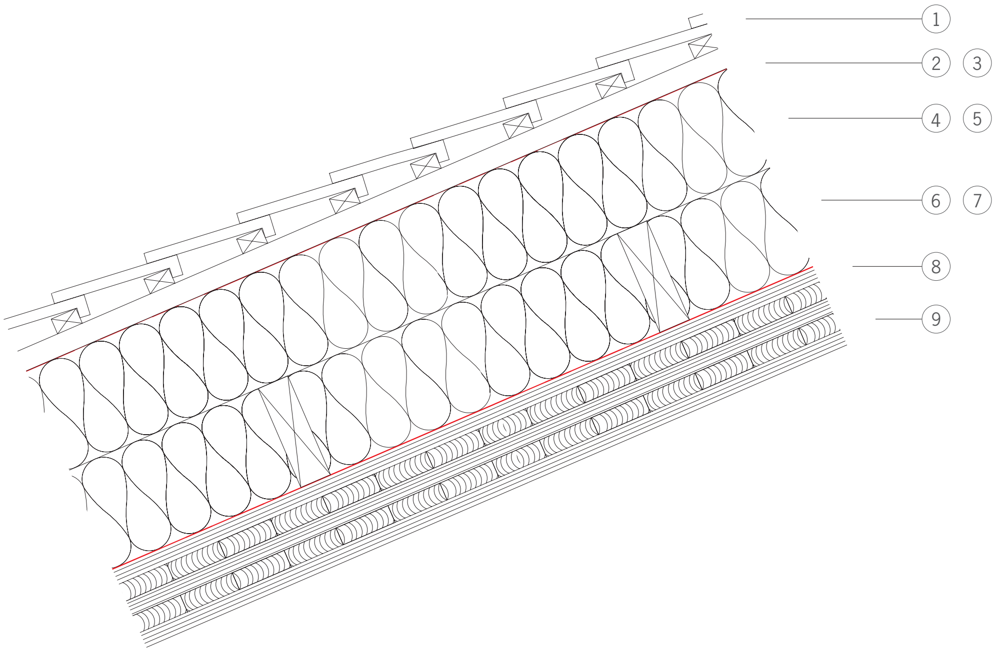
7.3.1 FLAT ROOF WITH KLH

	CONSTRUCTION MATERIALS	s [cm]	ρ [kg/m³]	[kg/m²]	μ [-]	s_d [m]	c [J/(kg*K)]	s' [MN/m³]	λ [W/(m*K)]	U_m-value [W/(m²*K)]
1	Gravel layer 16/32	...	...	...	...	...	...	...	...	
2	Polymer bitumen seal	0,2	...	4,30	40.500	...	987	...	...	
3	Insulation, pressure-resistant	34	20	6,8	1	0,34	1.030	...	0,040	0,10
4	Bitumen-aluminium layer	0,4	...	5,2	...	1.500	1.260	...	0,170	
5	KLH panel	14,5	500	72,5	25/50	...	1.600	...	0,130	



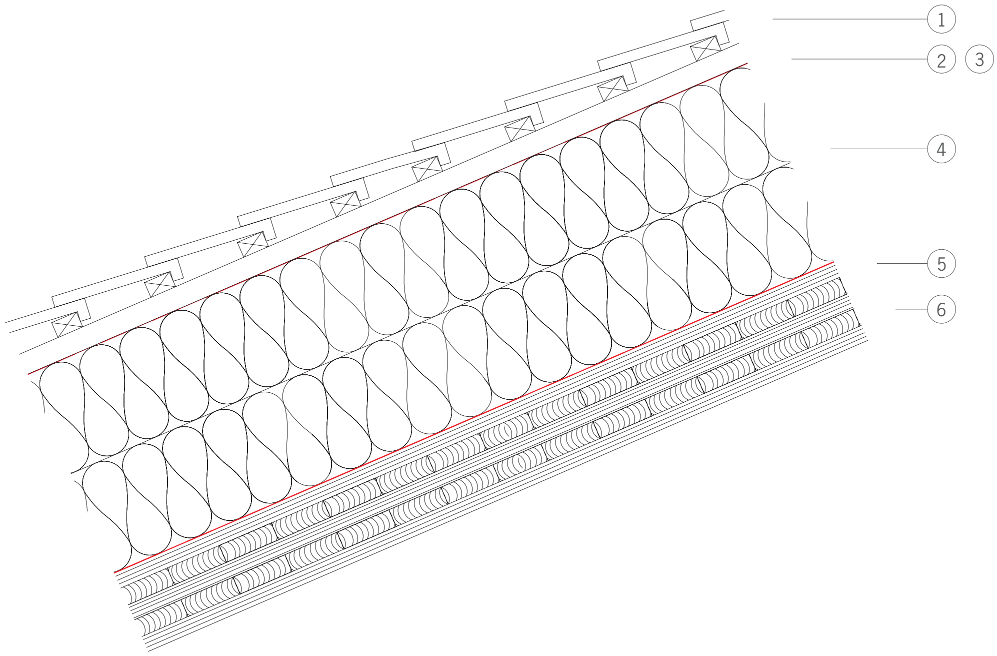
7.3.2 PITCHED ROOF WITH KLH – I-JOIST AND KLH

CONSTRUCTION MATERIALS		s	ρ		μ	s_d	c	s'	λ	U_m-value
		[cm]	[kg/m³]	[kg/m²]	[-]	[m]	[J/(kg*K)]	[MN/m³]	[W/(m*K)]	[W/(m²*K)]
1	Roof covering	...	...	...	...	...	...	...	...	0,10
2	Back ventilated air layer, vertical	4	...	...	...	...	...	...	...	
3	Wind proofing	0,05	...	0,5	22	0,01	1.000	...	0,170	
4	Insulation between webs	38	35	...	1	0,38	910	...	0,040	
5	Airtight layer	0,01	...	0,40	100.000	10	790	...	0,500	
6	KLH panel	14,5	500	72,5	25/50	...	1.600	...	0,130	



7.3.3 PITCHED ROOF WITH KLH – CROSS-LAMINATED TIMBER AND KLH

	CONSTRUCTION MATERIALS	s	ρ		μ	s_d	c	s'	λ	U_m-value
		[cm]	[kg/m³]	[kg/m²]	[-]	[m]	[J/(kg*K)]	[MN/m³]	[W/(m*K)]	[W/(m²*K)]
1	Roof covering	...	...	...	...	...	...	...	...	0,10
2	Back ventilated air layer, vertical	4	...	...	...	...	...	...	...	
3	Wind proofing	0,05	...	0,50	22	0,01	1.000	...	0,170	
4	Nogging piece 6x18, grid 0.625 m (vertical)	18	500	8,6	...	...	1.600	...	0,130	
5	Insulation between nogging pieces	18	35	5,7	1	0,18	910	...	0,040	
6	Nogging piece 6x20, grid 1.25 m (vertical)	20	500	4,8	...	...	1.600	...	0,130	
7	Insulation between nogging pieces	20	35	6,7	1	0,20	910	...	0,040	
8	Airtight layer	0,01	...	0,40	100.000	10	790	...	0,500	
9	KLH panel	14,5	500	72,5	25/50	...	1.600	...	0,130	

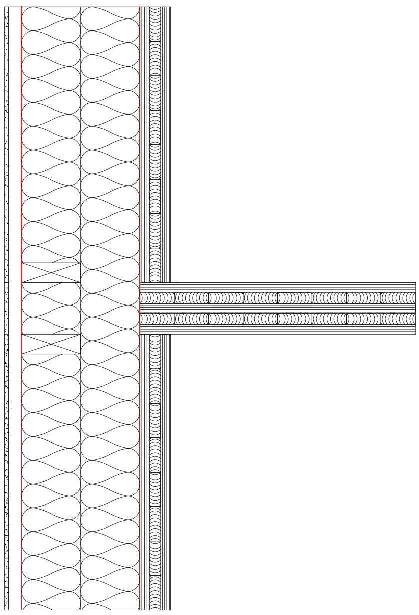


7.3.4 PITCHED ROOF WITH KLH – JAMMED INSULATION AND KLH

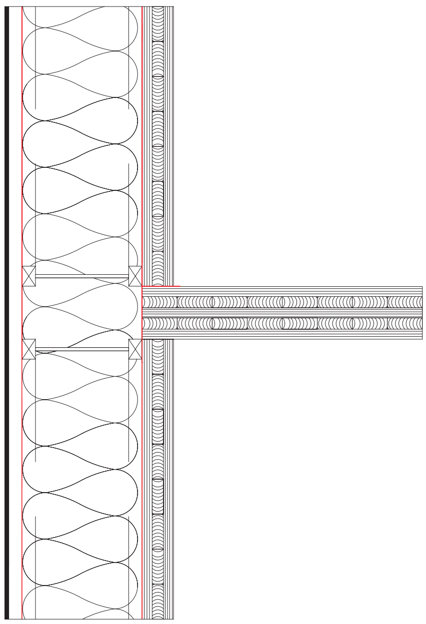
	CONSTRUCTION MATERIALS	s	ρ		μ	s_d	c	s'	λ	U_m-value
		[cm]	[kg/m³]	[kg/m²]	[-]	[m]	[J/(kg*K)]	[MN/m³]	[W/(m*K)]	[W/(m²*K)]
1	Roof covering	...	...	...	...	...	...	...	...	0,12
2	Back ventilated air layer, vertical	4	...	...	...	...	...	...	...	
3	Rain-proof under-roof membrane, permeable	0,05	...	0,50	22	0,01	1.000	...	0,170	
4	Insulation, pressure-resistant	34	150	51	1	0,34	1.030	...	0,040	
5	Airtight layer	0,01	...	0,40	100.000	10	790	...	0,500	
6	KLH panel	14,5	500	72,5	25/50	...	1.600	...	0,130	

08 COMPONENT CONNECTIONS

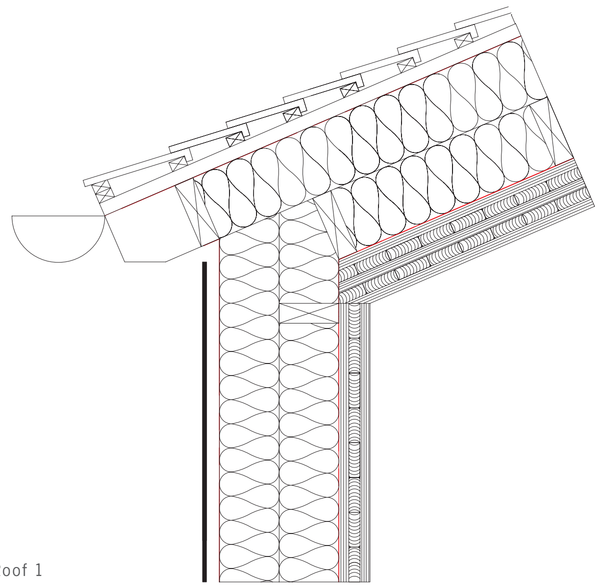
Some examples of component connections shall show how easily the "rule of the plotter pen" (comp. p. 12) can be realised during the planning without having to compromise on approved construction materials.



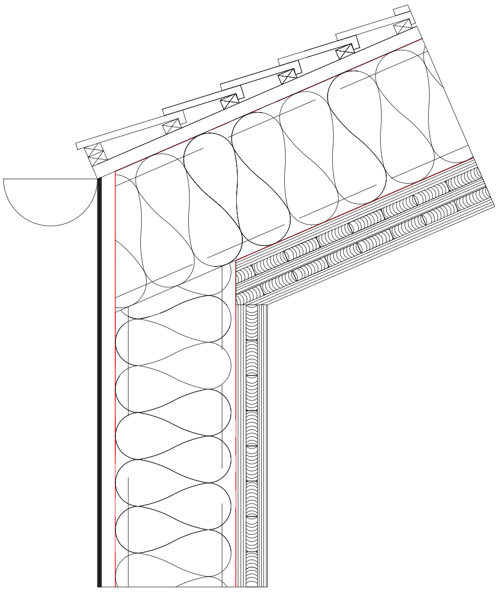
Ceiling 1



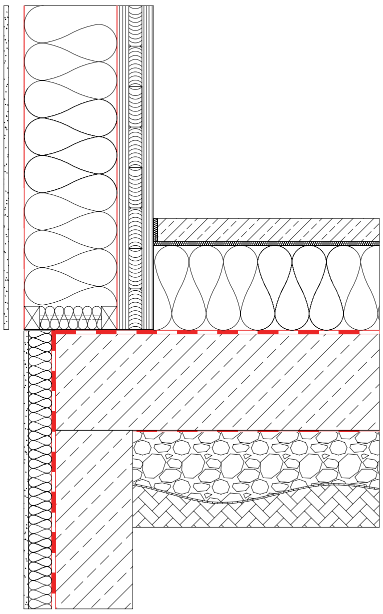
Ceiling 2



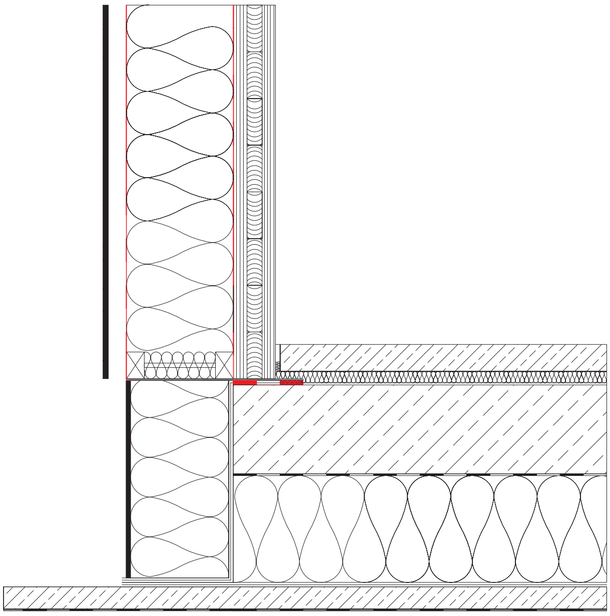
Roof 1



Roof 2



Base 1 – detailed condensation assessment necessary – see also chapter 02 “Highly heat-insulated external building components: floor slabs”



Base 2

LIST OF FIGURES & LIST OF SOURCES

Table 1: comp. Kaufmann, B., Feist, W., John, M., Nagel, M.: Das Passivhaus – Energie-Effizientes-Bauen, INFORMATIONSDIENST HOLZ, Holzbau Handbook Series 1, Part 3, Episode 10, Page 7, Publisher DGfH 2002

Table 2: www.passiv.de

Fig. 1: comp. Kaufmann, B., Feist , W., John, M., Nagel, M.: Das Passivhaus – Energie-Effizientes Bauen, INFORMATIONSDIENST HOLZ, Holzbau Handbook Series 1, Part 3, Episode 10, Page 9, Publisher DGfH 2002

Fig. 2: comp. Kaufmann, B., Feist , W., John, M., Nagel, M.: Das Passivhaus – Energie-Effizientes Bauen, INFORMATIONSDIENST HOLZ, Holzbau Handbook Series 1, Part 3, Episode 10, Page 9, Publisher DGfH 2002

Fig. 3: BSP Handbook – Chapter F: Bauphysik – Hochbau – Leitdetails Holz-Massivbauweise in Brettsperrholz – Nachweise auf Basis des neuen europäischen Normenkonzepts, Technische Universität Graz – holz.bau forschungs gmbh – Karlsruher Institut für Technologie – Technische Universität München – Eidgenössische Technische Hochschule Zürich

Fig. 4: BSPhandbuch – Kapitel F: Bauphysik – Hochbau – Leitdetails Holz-Massivbauweise in Brettsperrholz – Nachweise auf Basis des neuen europäischen Normenkonzepts, Technische Universität Graz – holz.bau forschungs gmbh – Karlsruher Institut für Technologie – Technische Universität München – Eidgenössische Technische Hochschule Zürich]

Fig. 5: Borsch-Laaks, R., Kehl, K., Images: EA NRW

Fig. 6: KLH

Fig. 7: www.passiv.de

Fig. 8: www.passiv.de

Fig. 9: Eberle • denkfabrik • from Dornbirn, Österreich

Fig. 10: Company pro clima 2011

Fig. 11: Company pro clima 2011

Fig. 12: www.passiv.de

Fig. 13: Eberle • denkfabrik • from Dornbirn, Österreich

Fig. 14: Eberle • denkfabrik • from Dornbirn, Österreich

Fig. 15: Eberle • denkfabrik • from Dornbirn, Österreich

Fig. 16: www.passiv.de

NOTES

NOTES

KLH MASSIVHOLZ GMBH
Gewerbestraße 4 | 8842 Teufenbach-Katsch | Austria
Tel +43 (0)3588 8835 0 | Fax +43 (0)3588 8835 20
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