STRAW BALE BUILDING GUIDELINES

English language version, 2020

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Acknowledgements

FASBA's Straw Bale Building Guidelines have now, five years after the publication of the original guidelines, been made available in a first revised version. Association members and recognised experts have been involved in the revision process.

Fachagentur Nachwachsende Rohstoffe e. V. (FNR) has made it possible to produce the Straw Bale Building Guidelines thanks to its sponsorship.

The revision of the Straw Bale Building Guidelines has been achieved within the framework of the EU-funded UP STRAW project with Benediktinerabtei Plankstetten as the German partner.

We wish to thank each and every one of these organisations for their support.

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Interreg North-West Europe
UP STRAW
European Regional Development Fund

- **Fachagentur Nachwachsende Rohstoffe e. V. (Ed.): Straw insulated buildings, Chapter 2: Building with straw is particularly sustainable. 2017**
- **ETA-17/0247 Baustroh (Building Straw), European Technical Assessment thermal insulation made from straw bales.**
- **Leaflet Instructions on processing Building Straw**
- **P-3048/817/08-MPA BS. General Building Inspectorate Test Certificate. Load-bearing, enclosing wall construction of fire-resistance class F 30 or F 90. English translation. Braunschweig: iBMB TU Braunschweig. 8.12.2014.**
- **Meyerhoff, C.: Expert opinion GA-2018-28, English translation, 2018.**

FOREWORD

These Straw Bale Building Guidelines summarise the experience and knowledge of players in the field of straw bale building in Germany. It has been compiled by experts and members of the *Fachverband Strohballenbau Deutschland e. V.* (FASBA) for those who are currently involved in constructing straw-insulated buildings and those who will be involved in this field in the future.

Their aim is to provide these individuals with a clear and comprehensive set of guidelines and thus set a quality standard for building with straw. It currently does not have the status of accepted technical rules.

The Straw Bale Building Guidelines relate, to the greatest possible extent, to constructions in which straw bales are used as infill, non-structural thermal insulation material. Numerous practical tried-and-tested straw-insulated constructions are listed here as proven and ready for approval.

Any other applications are also mentioned briefly.

The Straw Bale Building Guidelines were published in 2014 and the first revision took place in 2019. The conversion of the General Building Inspectorate Approval (*Allgemeine bauaufsichtliche Zulassung*) for construction grade straw bales (*Baustroh*) to a European Technical Assessment was updated, a short chapter on the sustainability of straw bale construction was added and more minor corrections and improvements were made to the text.

Currently (in 2019), 450 straw-insulated buildings are estimated to have been constructed in Germany. There are good reasons to build significantly more with straw in the future, above all the outstanding environmental performance of straw-insulated buildings.[1]

For FASBA:

Benedikt Kaesberg (text),

Dirk Scharmer (expertise),

Britta Imhoff (Board)

[1] See in the annex: Fachagentur Nachwachsende Rohstoffe e. V. (Ed.): Straw insulated buildings, Chapter 2: Building with straw is particularly sustainable.

FOREWORD TO THE ENGLISH LANGUAGE VERSION

Since its publication, people outside Germany have referred to these Straw Bale Building Guidelines. With its revision in 2019 and with the UP STRAW project aiming to upscale the use of straw in the building sector throughout Europe, it became important to translate these Guidelines into English.

As a national reference text, the Straw Bale Building Guidelines refer to both a particular building technique and to national building legislation. Most of the building aspects are common sense and valid everywhere. But due to different conditions (e. g. climate), moisture-proof constructions with straw insulation are not the same all over the world. That's why allowable moisture-dependent layer properties for constructions with straw as thermal insulation may be suitable in other parts of the world, but they are approved only for German climate conditions. The legal aspects refer to German building legislation, and any other countries' building legislation will be different. Specific legal terms are displayed both in German and in English, some footnotes give further information on the meaning of these terms. So, the reader can identify that there is a specific legal aspect and decide whether to adopt, adjust or disregard it for his or her purpose.

The translation aims to be as close as possible to the original text even though, its purpose is not to represent a scientific or literal translation. For instance, the term *Strohbau*, common in Germany, became Straw Bale Building for better understanding.

Hyperlinks of the original document are kept. If English language versions are available, but not online, footnotes refer to them in the annex.

These guidelines have been compiled and published by the Fachverband Strohballenbau Deutschland e. V., that is the German Straw Bale Building Association, a registered association and the only national organisation representing straw bale building in Germany. It is referred to as FASBA, and so it is in this text.

Feedback is welcome, through FASBA's webpage or facebook site.

May this English version of the Straw Bale Building Guidelines contribute to more straw bale building!

Benedikt Kaesberg (chairman translation)

Britta Imhoff (Board of FASBA)

Barbara Jones (proof reading)

1 GENERAL

The Straw Bale Building Guidelines are to be used in addition to the accepted technical rules.

The use of the following verbs refers to the meanings set out here:

Must: A provision with 'must' is mandatory.

Should: A provision with 'should' is to be complied with or, otherwise, reason is to be given why it is not being observed.

Can: A phrase with 'can' is used to set out options (for actions).

1.1 Terminology *Strohbau*

Strohbau ('straw building') refers to building with straw in general. Since building work with straw is usually carried out in the form of bales, the term *Strohballenbau* (straw bale building) is also commonly used.[2] In English, the term straw bale building is used, 'straw building' is not common.

1.2 Scope of these Guidelines

The Straw Bale Building Guidelines apply to straw as a building material within the meaning of the State Building Codes (*Landesbauordnungen*).[3] They require recognised construction products to be used. For straw in bale form, this is stated in ETA-17/0247 Building Straw or other approval document.

Alternatively, approval may also be obtained on a case-by-case basis (*Zustimmung im Einzelfall*).[4]

1.3 General requirements

Proper planning and implementation of straw-insulated buildings requires special physical, technical and manual construction knowledge. This should be carried out by experts who have received the appropriate training or are experienced.

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[2] Straw can also be used as a blown-in insulating material and as a bound insulating panel. Unlike with straw in bale form, this only carries out two of the three functions as thermal insulation, wall structure and base for plaster. It does not constitute a separate construction method. Rather, these building materials are versions of blown-in insulating materials and/or composite thermal insulation systems.

[3] Germany is a federal republic consisting of States (*Land* (sg), *Länder* (pl)) of whom each one has its own State Building Code (*Landesbauordnung*).

[4] The approval on a case-by-case basis (*Zustimmung im Einzelfall*) is an option for approval laid down in the State Building Codes. It applies only rarely and was initially the only way to obtain a building permit for a straw bale house in Germany. FASBA succeeded in establishing an easy approval for straw bale building with the recognition of the construction product "Building Straw". Regardless of that, the approval on a case-by-case basis remains possible.

2 STRAW AS A BUILDING MATERIAL

2.1 Definition of the term ‘straw’

Straw is defined as the dry stalks of cereals. The threshed ears usually remain on the stalks and are also part of the straw.

2.2 Grain varieties

To date, the domestic grain varieties of wheat, rye, spelt, wheat-rye hybrid and barley have been used for construction purposes. According to current knowledge, wheat and rye are particularly well-suited, whereas oat must be viewed as unsuitable.

2.3 Properties of the stalks

The natural properties of the stalks, in particular the length thereof, should be changed and/or damaged as little as possible by cultivation, harvesting and further processing.

The straw should be golden yellow to pale yellow. Straw which is somewhat grey and has isolated darkish areas as a result of mould which is no longer active can be seen as non-critical. The straw must not smell earthy or mouldy. The moisture content must be below the growth limit for mould.

The weed content of the straw is to be kept as low as possible.

2.4 Straw bale formats

In agriculture, straw is pressed into round or square bales to make transport, storage and further use easier. For straw bale construction, rectangular bales from agriculture are used. These are either made on the field during harvesting or re-baled at a later point in time.

Dimensions with a cross section of up to 40 cm by 50 cm are deemed small bales and bales which exceed these dimensions are deemed large bales. Small bales are currently most commonly used for construction with a width of approx. 48 cm and a height of approx. 36 cm depending on the baling type.

In the baling process, the width and height are generally not adjustable but the length is adjustable to a limited extent.

Large bales (e. g. mini-heston) can be installed faster, however they often require the use of machines and also more materials.

The dimensions of the straw bales must be used to determine the clear dimensions of the frame so that the straw bales can be installed tightly without any gaps.[5]

[5] For more information on this, see Chapter 5, Straw installation, and the Leaflet Instructions on processing Building Straw in the annex.

2.5 Storage and transportation of straw

Straw must be transported and stored in dry conditions. If necessary, it may only have brief contact with the ground and must be protected from rain.

When storing under tarpaulins, these must be permanently rainproof, including when subject to UV radiation and other stresses. There must not be any condensation dropping onto the straw from the underside of the tarpaulin, as this would affect the quality of the bale.

2.6 Straw as a building product

Thermal insulation materials must be recognised building products in accordance with State Building Codes (*Landesbauordnungen*) because they perform key tasks for a construction component. Within the meaning of the State Building Codes (*Landesbauordnungen*), straw is an unregulated building product like lots of other thermal insulation materials because no accepted technical rules exist for the material. It is either defined as having certain properties with the CE mark in accordance with ETA-17/0247 Building Straw or, if applicable, another approval document, or the use is approved on a case-by-case basis with the corresponding justifications for use.

2.7 Sustainability of straw bale building

Straw is a by-product created during grain cultivation. It grows every year and is regionally available. Approximately 20% of the straw harvest produced in Germany is not required. This quantity could be used to build up to 350,000 family homes. Manufacturing straw bales is possibly associated with low costs. In addition, wood, straw and clay can be reused.

Building with straw protects the environment by storing CO_2 with growth, with minimal CO_2 emissions being released during the manufacturing of straw bales and as thermal insulation in building operation thanks to the prevention of CO_2 emissions.

The environmental effects of straw as a building material are documented, for example, in the Environmental Product Declaration for Building straw. A life cycle assessment study of the environmental performance of straw-insulated buildings can be found in the “Straw-insulated buildings” brochure, Chapter 2, published by the Fachagentur Nachwachsende Rohstoffe e. V.[6]

[6] See in the annex.

3 PHYSICAL CONSTRUCTION PROPERTIES

The following section covers the physical construction properties of straw and straw-insulated construction components.

The chapter is aligned with the general construction standards necessary under the following headings.

3.1 Fire protection

3.1.1 Building material class

In accordance with the State Building Codes (*Landesbauordnungen*), building materials may only be used if they can be classified as having at least normal flammability (B2) in accordance with DIN 4102 or Class E in accordance with DIN EN ISO 11925-2 or, in exceptional cases, if this can be achieved in an equivalent way by the method of installation.

Building straw is, in accordance with ETA-17/0247 Building Straw, to be assigned to building material class E. For this, the minimum straw density, in particular, must not fall below 85 kg/m³.

The surface flammability may, for example, be reduced with a plaster coat. By means of a clay plaster coat which is at least 8 mm thick, a straw-insulated wall can achieve “B, s1, d0” in accordance with DIN EN 13501-1:2007. Due to the additional usability proof which is required in Germany in accordance with DIN 4102 for this testing type which is regulated on a European basis, Building straw is, however, only classified as having a normal level of flammability, even with this finish.

3.1.2 Resistance to fire

The fire-resistance class states the duration in minutes that the classified construction component can withstand during a full fire in standardised testing. Key criteria are the maintenance of the room seal, the structural stability and temperature protection.

A load-bearing straw-insulated timber stud wall can be classified in fire-resistance classes in accordance with DIN 4102-2:1977-09. For this, it must meet all the conditions of the General Building Inspectorate Test Certificate (*allgemeines bauaufsichtliches Prüfzeugnis*) set out below. With clay plaster that is at least 8 mm thick, F 30-B is achieved, and F 90-B is also achieved with lime plaster.

Load-bearing fire-resistant external wall F 30-B and F 90-B in accordance with the General Building Inspectorate Test Certificate (*allgemeines bauaufsichtliches Prüfzeugnis*) P-3048/817/08-MPA BS, 2014, updated in 2019.[7]

Fire-resistant straw-insulated construction components can also be created if corresponding proof is provided by the covering alone and without the specification of other components.

3.2 Thermal insulation

3.2.1 Thermal conductivity

The thermal conductivity λ [W/(m·K)] of a material denotes the heat (J) which is transmitted through one square metre of a material which is 1 m thick, at a temperature difference of one degree kelvin, per second.

For the approved building product of "Building Straw" in accordance with ETA-17/0247 Building Straw, the declared value of the thermal conductivity, valid throughout the EU, is:

λ_D = 0.048 W/(m·K) according to ETA-17/0247 Building Straw

The rated value of the thermal conductivity, defined differently by a national calculation procedure in each of the EU member states, to be used for the calculations for Germany is:

$\lambda_{R,\ Germany}$ = 0.049 W/(m·K) according to ETA-17/0247 Building Straw[8]

This value applies for the orientation of the stalks within the construction component in a direction predominantly vertical to the heat flow. Therefore, bales are installed either horizontally or vertically on edge. (See figures in 4.1.7) A recognised rated value for the orientation of the stalks in the direction of the heat flow currently does not exist.

3.2.2 Thermal transmittance coefficient

The thermal transmittance coefficient U [W/(m²·K)] denotes the thermal flow in watts with a temperature difference of one degree kelvin through one square metre of the surface area of the construction component. This is a result of the properties of the layers of the construction component.

[7] See English version in the annex.

[8] The calculation takes place in accordance with the Model Administrative Provisions – Technical Building Rules (*Muster-Verwaltungsvorschrift Technische* Baubestimmungen (MVV TB)), Annex A 6.2/3, as follows:

$\lambda_R = \lambda_{10,dry,\ 90/90} \cdot F_{m\ (dry\ -\ 23/80)} \cdot 1.03 = 0.043\ W/(m\cdot K) \cdot 1.1 \cdot 1.03 = 0.048713\ W/(m\cdot K) \approx 0.049\ W/(m\cdot K)$

Straw-insulated components achieve U values of 0.155 W/(m²·K) and below. Thus the standard requirements are met or exceeded.

3.2.3 Specific heat capacity

The specific heat capacity c [kJ/(kg·K)] of a material denotes the energy that is required to heat one kilogram of the material by one degree kelvin.

The specific heat capacity of typical cereal straw is:

c = 2.0 kJ/(kg·K) TGL 35424/02 Bautechnischer Wärmeschutz (Structural heat insulation. Values, Units, Characteristics.), 1981.

3.2.4 Specific flow resistance

The specific flow resistance Rs [Pa s/m] refers to the ratio of the pressure difference Δp [Pa] in front of and behind a material layer to the speed of the air passing through. This property of a building material influences the thermal conductivity and the airborne sound insulation.

The specific flow resistance of Building straw can be assumed with:

Rs = 181 Pa s/m according to IAB Messbericht (test report) A 59829/3950, 25.9.2009

3.3 Acoustic insulation

3.3.1 Airborne sound insulation index of a straw-insulated external wall

The airborne sound insulation index R'_W is a logarithmic measure and describes the ability of a construction component to insulate sound. The airborne sound insulation values measured in the 16 1/3-octave bands between 100 Hz and 3150 Hz for a construction are entered into a diagram by frequency. In order to determine the airborne sound insulation index R'_W, this curve is used to determine a single-number value using a standardised reference curve.

Example wall I with plaster at 1 cm thickness, 36 cm straw, 6 cm/30 cm posts with 2 cm of wood fibre insulation board as the plaster base on each side

$R_{w,R}$ = 43 dB (calculation value according to DIN 4109:1989 Tab. 11)

IAB Messbericht (test report) A 59829/3950, 25.09.2009

Example wall I with plaster at 1 cm thickness on one side and 2 cm on the other side, 36 cm straw, 6 cm/30 cm posts with 2 cm of wood fibre insulation board as the plaster base on each side

$R_{w,R}$ = 44 dB (calculation value according to DIN 4109:1989 Tab. 11)

IAB Messbericht (test report) A 59829/3950, 25.09.2009

The values which are given are only examples. Property-related investigations and proof are recommended for compliance with specific sound insulation requirements for straw-insulated external walls.

3.4 Moisture protection

3.4.1 Water vapour diffusion resistance factor

The dimensionless water vapour diffusion resistance factor μ specifies by which factor the material in question that protects against water vapour is less permeable than a stationary air layer of the same thickness.

μ = 2 according to ETA-17/0247 Building Straw

The air layer thickness s_d [m], which is equivalent to the water vapour diffusion, is the product of the water vapour diffusion resistance factor μ and the material thickness d.

s_d = μ x d

3.4.2 Proof of suitability for providing moisture protection

From a technical moisture perspective, a straw-insulated construction component can be proven by means of a biohygrothermal evaluation of the annual moisture and temperature curve at a depth of 5 cm, measured from the straw edge on the external side.

In order to determine a safe and mould-free area of application, according to Sedlbauer, temperature, moisture content and substrate are taken into account as growth factors. Straw is assigned to substrate class I. The temperature and moisture curve within the straw insulation is determined by means of transient modelling (e.g. with WUFI®) (or metrologically on existing components). The values which are obtained are then subject to a mould risk evaluation with WUFI-Bio.[9]

In Annex B ETA-17/0247 Building Straw, layer properties are described for straw-insulated construction components. These have been determined using this procedure. See Section 4.2.

[9] See Krus, Künzel and Sedlbauer, applied in Klatecki.

4 BUILDING WITH STRAW

4.1 Requirements for planning and construction

4.1.1 General requirements

The general requirements for construction, e.g. safety on the building site, structural stability, fire, moisture, heat and sound protection, as well as protection against harmful influences, must be observed.

4.1.2 Fire protection

The requirements regarding the fire protection properties of building materials and construction components are set out in the respective State Building Code (*Landesbauordnung*). As an insulating material with a normal flammability level, straw meets the minimum requirements for building materials. When clad with suitable building products, straw-insulated construction components can achieve the fire-resistance class F 30-B fire-resistant and/or F 90-B according to DIN 4102-2 provided that General Building Inspectorate Test Certificates are available for the respective combination of building materials and are observed during construction. (For more details, see Section 3.1.2.)

4.1.3 Weather protection and moisture protection

Straw-insulated construction components must provide permanent protection against weather conditions from the outside. With external walls, this is ensured using back-ventilated cladding or crack-proof, weather-proof lime plaster with a breathable, hydrophobic coating to provide protection against driving rain.

External walls can also be protected additionally against weather conditions using roof overhangs.

Base areas of external walls with straw insulation must be permanently sealed to protect against rising moisture. The straw and the lowest parts of the wooden construction must be above the areas which are exposed to splashing water.

Windows and window sills must be installed such that rainfall and splashing water running down the facade cannot get in at the joints. Underneath the windowsill, a sealing layer which has raised edges below the window frame and in the recesses must be installed.

Further requirements can be found in DIN 68800.

4.1.4 Air-tightness and wind-tightness

For all external construction components, the air-tight level on the inside and the wind-tight level on the outside, including connections, gaps and penetrations of all construction

components (for example due to installations), must be carefully planned and installed in accordance with DIN 4108-7:2011-01 to ensure long-term safety.

A blower door test with leakage location should be carried out to prove the implementation quality.

4.1.5 Thermal bridge reduction

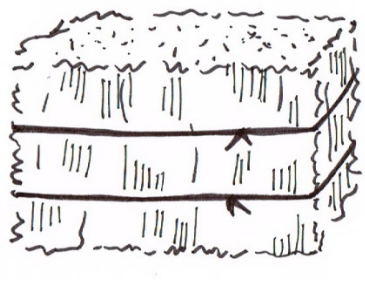
Thermal bridges are to be reduced using suitable measures, for example by sufficiently insulating each of the construction components. This applies, in particular, to connections of external wall to windows and doors, but also to the integration of false ceilings into the external wall, as well as to all other transitions between construction components.

4.1.6 Moisture transport

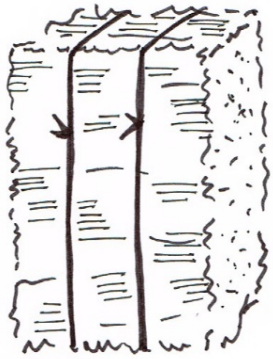
In the external area of a straw-insulated construction component in particular, moisture transport must be ensured between the individual layers of the construction component. In order to ensure that no condensation accumulates on the outside of the straw insulation in unspecific construction cavities, the construction component must be insulated without any gaps and the cladding must be sealed and not have any cavities. The external side of the straw surface should not be covered directly with a membrane but, rather, with a capillary absorbent building material, e.g. plaster or wood fibre insulation boards.

4.1.7 Stalk direction

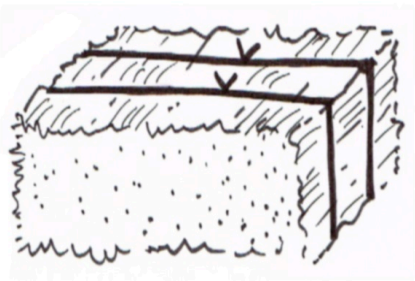
Optimum thermal insulation of straw is achieved with a stalk direction which is predominantly vertical to the heat flow. Straw bales must therefore be installed in vertical construction components with the edge upright or horizontal and lying flat in ceilings and roofs.



vertical on edge



horizontal on edge



flat

Installation with a stalk direction in the direction of the heat flow is technically possible; ETA-17/0247 Building Straw does not include a value for thermal conductivity for this.

4.1.8 Support structure and reinforcement

The proof of structural stability and the usability of a building (*Nachweis der Standsicherheit und der Gebrauchstauglichkeit*), including the reinforcement requirements, do not take straw into consideration. With timber and board constructions, horizontal forces are absorbed by suitable, approved board materials, or by diagonally installed compression and/or tension elements out of timber (struts/braces/shores) or metal (steel strap). They can also be diverted via an engineered connection to reinforcing construction components, for example internal walls.

4.1.9 Straw bale formats and frame size

The internal frame size should be determined in accordance with the dimensions of the straw bales.[10] Other sizes are possible. The determination of the suitable internal frame span as a grid should take place at an early stage and in a precise and reliable manner. Planning deficiencies would cause significant additional work here. See 5.1.2.

4.1.10 Installations

Electrical installations should not be laid through the straw but, rather, covered with non-flammable materials, e.g. plaster.

In order to prevent moisture damage, water-carrying installations should be installed outside straw-insulated construction components.

4.2 Suitable construction components

4.2.1 General

Building straw is used as thermal insulation for filling within load-bearing or non-load-bearing constructions.

It must not carry compressive loads and must not perform any structural stability of the construction or parts thereof.

Building straw is installed with a support spacing of less than one metre inside clear width.

Plaster can be applied directly to the surfaces made from compressed straw.

Straw can be used both for new constructions and for the renovation of existing buildings.

4.2.2 Components

Straw is used in external walls, back-ventilated roofs and final storey ceilings. The frame can be formed by the load-bearing structural components. For external walls, solid timbers have

[10] For more information, see the Leaflet Instructions on processing Building Straw in the annex.

become widely used for this, the clear distance of which results from the dimensions of the straw bales and does not exceed 1.0 m. Their depth corresponds to the insulation thickness, and can be doubled if required. This also applies for roofs and the final storey ceilings allowing for the respective requirements for the construction components.

4.2.3 Allowable layer properties

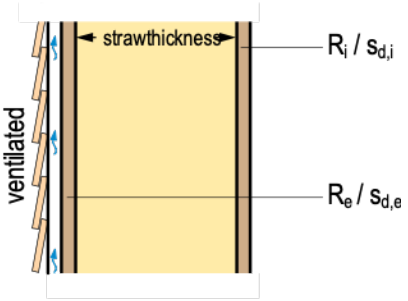
The suitability of straw-insulated construction components is largely dependent on their moisture proofing quality. There must be no harmful mould growth within these components. Depending on the temperature, the moisture quantities must be kept sufficiently low by means of compliance with certain layer properties. It can be assumed that straw-insulated construction components are suitable if the properties of the individual layers correspond with the specifications set out in Annex B ETA-17/0247 Building Straw.

Note: According to Annex A ETA-17/0247 Building Straw, this is valid for climate conditions in Germany. Climate conditions elsewhere must not, but can restrict these allowable layer properties. Suitability for providing moisture protection can be proven with the procedure described in 5.2.4 by taking other climate conditions into consideration.

Allowable moisture-dependent layer properties for structures with straw as thermal insulation in Germany (Annex B ETA-17/0247 Building Straw)

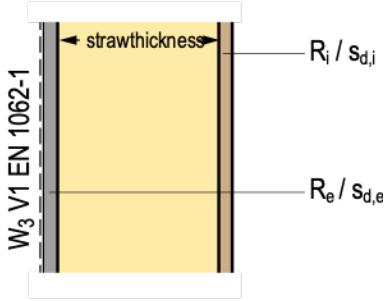
a) Exterior wall structures with back-ventilated external cladding for weather protection

Line	Straw thickness [m]	$s_{d,i}$ [m]	R_i [m²·K/W]	$s_{d,e}$ [m]	R_e [m²·K/W]
1	≤ 1.00	**≥ 0.10**	**≤ 0.35**	**≤ 0.50**	**-**
2	≤ 0.48	**≥ 0.76**	*≤ 3.14*	≤ 0.50	-
3	≤ 0.48	≥ 0.10	≤ 0.35	*≤ 1.00*	**≥ 1.00**
4	≤ 0.48	**≥ 2.00**	≤ 0.35	*≤ 1.50*	**≥ 0.70**
5	≤ 0.48	≥ 0.10	≤ 0.35	*≤ 1.50*	**≥ 1.43**
6	≤ 0.48	≥ 0.10	≤ 0.35	*≤ 2.00*	**≥ 1.90**



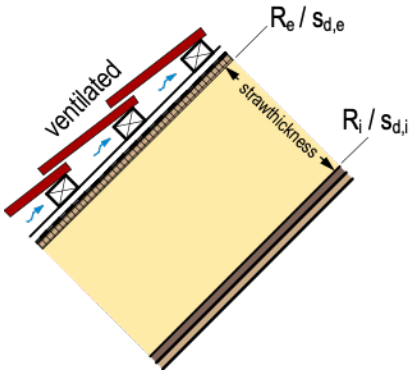
b) Plastered exterior wall structures with no weather protection
Plaster in accordance with EN 998-1 with water-repellent coating in accordance with EN 1062-1 in W_3 and V_1

Line	Straw thickness [m]	$s_{d,i}$ [m]	R_i [m²·K/W]	$s_{d,e}$ [m]	R_e [m²·K/W]
1	≤ 0.70	**≥ 0.10**	**≤ 0.35**	**≤ 0.50**	**-**
2	≤ 0.48	**≥ 0.76**	*≤ 3.14*	≤ 0.50	-
3	≤ 0.48	**≥ 3.00**	≤ 0.35	*≤ 1.50*	**≥ 0.30**



c) Roof structures with ventilated roofing

Line	Straw thickness [m]	$s_{d,i}$ [m]	R_i [m²·K/W]	$s_{d,e}$ [m]	R_e [m²·K/W]
1	≤ 0.48	**≥ 2.00**	**≤ 0.35**	**≤ 0.50**	**≥ 0.14**
2	**≤ 0.36**	**≥ $s_{d,e}$**	≤ 0.35	*≤ 3.00*	≥ 0.14



Note:
Line 1 characterises the allowable basic version.
Additional lines: possible versions with modified element characteristics (with grey background) which in turn require modified layer characteristics (values shown in bold).

Symbols, indices:

$s_{d,e}$ diffusion-equivalent air layer thickness for the external layers / cladding
$s_{d,i}$ diffusion-equivalent air layer thickness for the internal layers / cladding
R_i thermal resistance for the internal layers / cladding
R_e thermal resistance for the external layers / cladding
W_3 water permeability of coating classified acc. to EN 1062-1 and tested acc. to EN 1062-3: $W_{24} \leq 0.1$ kg/(m²·√h); Index 24 = test duration of 24 h
V_1 water vapour flux density of coating classified acc. to EN 1062-1 and tested acc. to EN 1062-3: $V_1 > 150$ g/(m²·d) with $s_d < 0.14$ m

Explanation of Annex B ETA-17/0247 Building Straw

Annex B details the biohygrothermal suitability of straw-insulated constructions depending on their building material properties. The tables provided for the three construction component types contain the necessary layer properties for preventing harmful mould growth in the relevant outer area of the straw insulation. For this, growth conditions for the germination of spores must not be created by water vapour diffusion[11] from the inside into the straw insulation or from rain from the outside in connection with the given temperatures relating to the climate and construction component. From a construction perspective, this can only be achieved via a combination of suitable thermal resistances inside, outside and of the insulation itself (specified in the Annex in a simplified manner as the straw thickness), and via suitable diffusion-equivalent air layer thicknesses of the internal and external finish and the straw insulation itself (also indirectly contained in the straw thickness).

With the tables in Annex B and the information below, experts are provided with the information they need to plan construction components which are allowable from a moisture-proofing perspective and/or check the permissibility of a component construction from a moisture-proofing perspective. The following information sets out the different scenarios relating to the physical construction parameters from the tables using the example of the exterior wall structures pursuant to Table a).

Straw-insulated external wall constructions with back-ventilated weather protection are allowable from a moisture-proofing perspective in accordance with Table a) Annex B as set out below:

> ***Line 1:*** *If the straw thickness is not greater than d = 1 m and if, at the same time, the construction component layers between the straw insulation and the outdoor climate demonstrate a diffusion-equivalent air layer thickness of a maximum of* $\boldsymbol{s_{d,e}}$ ***= 0.5 m*** *and the construction component layers between the straw insulation and the interior space feature a diffusion-equivalent air layer thickness of at least* $\boldsymbol{s_{d,i}}$ ***= 0.1 m*** *and a thermal resistance of a maximum of* $\boldsymbol{R_i}$ ***= 0.35 m²·K/W****, then the construction component is allowable.*
>
> ***Line 2:*** *If, in contrast with this, the room-side layers feature a higher thermal resistance of up to* $R_i = 3.14\ m^2 \cdot K/W$ *, e.g. because the straw insulation was installed in front of masonry, then the diffusion-equivalent air layer thickness inside is to be increased to at least* $\boldsymbol{s_{d,i}}$ ***= 0.76 m****. The straw thickness may be no more than d = 0.48 m for this.*

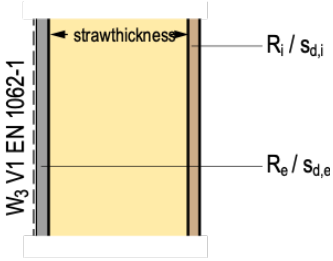
[11] Convective entry is to be excluded anyway. (See ETA-17/0247 Building Straw, Annex A, 4) on joint tightness of the inner cladding.)

Line 3: *If the outer layers on the outside, in deviation from the example construction in Line 1, demonstrate a diffusion-equivalent air layer thickness of up to $s_{d,e}$ = 1.0 m, then the thermal resistance of the outer layers is to be increased to at least* ***R_e = 1.0 m²·K/W****. The straw thickness may be a maximum of d = 0.48 m for this.*

All further lines and tables follow the same logic.

Exterior wall constructions with direct weather exposure and plaster must contain plaster according to DIN EN 998-1 with a water-repellent coating according to DIN EN 1062-1 in W_3 and V_1.

Review of an intended construction component



An exterior wall construction with direct weather exposure and plaster should be created and checked with regard to its permissibility according to Annex B. The exterior wall construction should have the following properties:

- Straw thickness d=0.36 m,
- 3 cm lime plaster inside with a water vapour diffusion resistance factor of μ = 10 and thermal conductivity of λ = 0.70 W/(m·K),
- 3 cm lime plaster according to DIN EN 998-1 on the outside with a water vapour diffusion resistance factor of μ = 10 and thermal conductivity of λ = 0.80 W/(m·K),
- Facade coating, identified either directly with the classifications W_3 and V_1 or $w_{24} \leq 0.1$ kg/(m²·√h) and V > 150 g/(m²·d) with $s_d < 0.14$ m.

The physical construction parameters move in accordance with Table b), Line 1, Annex B ETA-17/0247 Building Straw:

Diffusion-equivalent air layer thicknesses $s_d = d \cdot \mu$ [m]
External: $s_{d,\,e,\,present} = 10 \cdot 0.03$ m + 0.13 m= 0.43 m ≤ $s_{d,\,e,\,allowable}$ = 0.5 m
Internal: $s_{d,\,i,\,present} = 10 \cdot 0.03$ m = 0.3 m ≥ $s_{d,\,i,\,allowable}$ = 0.1 m

Thermal resistance R = d / λ [m²·K/W]
External : R_e no requirement
Internal: $R_{i\ present}$ = 0.03 m / 0.8 m·K/W = 0.038 ≤ $R_{i\ allowable}$ = 0.35 m²·K/W

Results: The construction is allowable according to Table b), Line 1, Annex B ETA-17/0247 Building Straw because all the layer properties are maintained in the combination as shown above, the external plaster meets the requirements and a suitable facade coating is used.

4.3 Further construction components

4.3.1 Miscellaneous

The suitability of straw in external construction components which do not comply with Annex B ETA-17/0247 Building Straw, for example non-filling or pressurised constructions, other layer properties or other areas of application must be proven separately.

In particular, the following applications are deemed to be other areas of application in this regard:

- any type of pressure load on straw by a dead load or traffic load or by component reinforcement;
- layer properties which deviate from Annex B ETA-17/0247 Building Straw (The suitability from a moisture-proofing perspective must be proven here, e.g. by means of a biohygrothermal evaluation with WUFI® and WUFI-Bio.);
- Attached external wall insulation: When straw is to be installed without clearly defined frame as a continuous prefixed insulation layer in front of external walls (mechanical strength in the compartment);
- Internal walls: When straw is to be installed in internal walls (behaviour in a permanent indoor climate without guaranteed joint tightness to the indoor environment);
- Non-ventilated roof areas: When straw is to be installed in non-ventilated roof spaces (moisture-proofing suitability);
- Top-floor ceilings: When straw is to be installed above upper storey ceilings without defined compartment formation and/or pressurised (mechanical strength);
- Floor panels and basement ceilings: When straw is to be installed in floor panels or in ceilings against an unheated basement and/or is to be used in a pressurised manner (moisture-proofing suitability, mechanical suitability).

4.3.2 Load-bearing construction

The term ‘load-bearing straw bale construction’ is used to describe a construction method in which some or all of the load-bearing components are straw bales (in wall or vault constructions). The bales are compressed and perform tasks relating to the structural stability of the built structure.

The construction method originates from Nebraska and was first used there in approximately 1880 after the invention of the baling machine. It is now used all over the world.

In Germany, there are no generally applicable procedures and measurement concepts for ensuring the structural stability and usability of buildings with load-bearing components made from straw bales. The approval and proof of suitability must take place by means of permission

on a case-by-case basis. The request for this can be made to the respective Highest Building Inspectorate (*Oberste Bauaufsicht*) in the State.[12]

[12] The state of the art in terms of knowledge about load-bearing construction with straw in Germany is documented at: http://fasba.de/wp-content/uploads/2016/05/Lasttragendes-Bauen-Stand-des-Wissens-2009-2014.pdf
There is no English version available.

5 STRAW INSTALLATION

5.1 Requirements for straw installation

5.1.1 Straw bales suitable for building

Straw bales suitable for building have a golden yellow to pale yellow appearance. The surfaces are even and perpendicular to one another. The edges are straight and not rounded. The strings must be tight, the front side may be dented somewhat and must not come out of the bale during transport.

They are baled in a compact manner and hold their shape. A flat hand cannot, or can only with difficulty, be pushed between the individual courses of a bale. The straw bales must be installed according to ETA-17/0247 Building Straw with a density of between 85 kg/m^3 and 115 kg/m^3 in a reference climate of 23 °C and 50% relative humidity.

Bales which are not suitable for building would require significant extra work, such as re-baling or stuffing remaining cavities after installation. In addition, this would cause uneven compression, and/or dents and bulges in the straw surfaces, and therefore also increased thickness for plaster application.

Damp, mouldy straw which smells earthy or has active mould growth must not be used for installation.

These properties are identified for an approved building product of Building straw; if other straw bales are used within the framework of approval on a case-by-case basis, these must be checked for suitability.

5.1.2 Installation situation

The support distance and wall thickness should be suitable for the straw bale dimensions.
For special geometric installation situations (e. g. pediment, special compartments), straw bales can be made shorter and notched or beveled.

5.1.3 Seasonal conditions

In principle the installation of straw is possible throughout the year if there is sufficient moisture protection during construction.

The seasonal conditions for drying are to be taken into account for plastering.

5.2 Requirements for installed straw

5.2.1 Installation

Straw must be installed without any gaps and with no possibility of settlement. In order to ensure this, straw should be compressed during installation. Any remaining cavities are to be tightly packed and well stuffed with loose straw.

In a frame, straw must be secured using suitable means to ensure that it does not become detached or fall out.

Straw must be installed with a density of between 85 and 115 kg/m³ for a normal climate (23 °C/50% relative humidity).

Any other densities constitute a defect and require approval on a case-by-case basis because no recognised rated value for thermal conductivity is available for this. If the density is too low, it is also no longer recognised as a building material with normal flammability (class E).[13]

5.2.2 Evenness of straw surfaces

The straw surfaces should be made flat and straight after installation. Any major unevenness must be corrected first. Then the straw surfaces are trimmed identically.

Major unevenness requires extra work and may cause problems that reduce the quality of the cladding.[14]

5.3 Protecting straw-insulated components during construction

5.3.1 Protection against precipitation

Straw-insulated construction components must be protected in a proper manner (e.g. with tarpaulins) until the cladding which provides protection against rainfall and splash back has been finished.

Unfinished base areas and wall openings must also be protected against rainfall.

Observe DIN 68800 Parts 1-4.

5.3.2 Fire protection on building sites

Stored, as well as installed, straw bales which have not yet been clad, plus loose straw, must be protected against fire and sparks.

Smoking is prohibited on the building site during straw installation and until the straw surfaces have been covered.

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[13] See Section 3.2.1 Thermal conductivity and ETA-17/0247 Building Straw.
[14] See Section 6.2 Plaster .

Any loose straw is to be placed in closed sacks or containers, temporarily stored at a sufficient distance from the building site and disposed of at least once a week.

In order to improve the fire protection, the first layer of covering should be applied to straw-insulated construction components as early as possible.

6 FINISHES FOR STRAW

6.1 Tasks and requirements

6.1.1 General

Finishes of construction components are necessary to achieve and comply with all general protection targets relating to the field of construction, e.g. fire protection, thermal insulation, moisture-proofing and durability, as well as, in particular, requirements in terms of air-tightness and wind-

rtightness and weather protection. This must be carefully planned and installed in a professional manner.

Internal and external finish of straw-insulated construction components must comply with Annexes A and B ETA-17/0247 Building Straw or require other proof of suitability, e.g. approval on a case-by-case basis.

6.1.2 Protection against infestation by rodents and insects

Straw-insulated buildings which have been installed in a professional manner are not at particular risk of infestation by small animals and insects.

Finishes on straw insulation can be counted as sufficient protection against infestation by rodents and insects if it is free of cracks, air-tight and wind-tight and has a sufficient thickness and mechanical strength. When observing recognised rules and manufacturer specifications, in accordance with previous experience, this corresponds to the following layer thicknesses, for example:

Lime plaster: ≥ 2 cm, clay plaster: ≥ 2 cm, wood: ≥ 1.5 cm, medium density wood fibre boards: ≥ 1.5 cm, wood fibre insulation boards: ≥ 2 cm

6.1.3 Surfaces

Finishes seal straw-insulated construction components from the inside and outside and provide surfaces which have an aesthetic and are usable. They shape the appearance of rooms and buildings. Finishes must be installed such that they can withstand long-term use. Fixing is to be carried out according to the materials being used and, with heavy objects, timely planning and preparation is required.

6.1.4 Regulating the indoor climate

The internal finish of straw-insulated construction components has a significant influence on the room temperature and the room air humidity and therefore affects the indoor climate. Hygroscopic structural materials (especially clay) store moisture and emit this again over time.

They therefore create balance when the moisture level varies. Heavier structural materials store heat and emit this again over time. They therefore create balance when the temperature level varies in the summer and winter.

6.2 Plaster finishes

6.2.1 Tasks

Plaster serves as an air-tight or wind-tight layer of the construction component. With the appropriate installation in accordance with the General Building Inspectorate Test Certificate MPA BS P-3048/817/08, 2014,[15] updated 2019, together with the straw/wood construction, it can form a fire-resistant load-bearing external wall, protect against infestation by pests, provides a usable and aesthetic boundary and regulates the indoor climate.

6.2.2 Requirements

The straw must be sufficiently thick, installed securely and without any cavities. The straw surface must be as even as possible and free from loose straw parts.

Clay plasters have become widely used inside, as well as outside behind a mounted facade and lime plasters have become widely used outside. They should be relatively soft (compression strength class CSI according to DIN EN 998-1) so that they remain operational with minor and standard structural movements.

As a sole finish component, plasters must be rubbed, smoothed or sponged and be at least 2 cm thick.

6.2.3 Requirements for installation

Clay plasters must be used in a professional manner pursuant to DIN 18947 or in accordance with the Clay Construction Guidelines (*Lehmbauregeln*) or, for lime plasters, DIN 998-1. Among lime plasters, standard plastering mortars can be used as well as lightweight plastering mortar, both in the form of premixed, dry mortars.

For lime plasters, each layer must dry for a sufficiently long period of time and must carbonate sufficiently. If necessary, lime plaster must be watered. Sintered layers must be removed mechanically and in good time because they would impair the moisture transport and the adhesion.

The individual application layers of the plaster must not be too thick and suitable drying conditions must be provided.

[15] See the English version in the annex.

Plaster surfaces which serve as an air-tight or watertight layer of the construction component must be fully reinforced to ensure sufficient prevention of cracking. Fibres can be added to contribute to that. Connections to other finishes or construction components, such as ceilings or internal walls, must be air-tight and wind-tight.

In order to prevent moisture entry into the straw insulation from being too high, constructions with plaster must dry sufficiently quickly and comprehensively. Long drying times in weather conditions which are too cold should be avoided. Where necessary, the drying process must be supported with lots of ventilation or the use of fans, heaters, drying and dehumidification devices.

For layer thicknesses of the internal plaster of above 1.5 cm, a person should be appointed to be responsible for monitoring the drying process and documenting this accordingly.[16]

Weather-related and seasonal restrictions are to be taken into consideration.

6.2.4 Processing

Plaster adhesion on straw is achieved with a physical grip. The first plaster coat must be sufficiently rich in binding agents and liquid. It carries all the other plaster layers and must be applied carefully. On other plaster surfaces, such as wood, a base for plaster must be used (e.g. reed fabric, wood fibre insulation boards). The first plaster layer follows the contours of the straw surface and does not need to form an even surface.

An even surface is created with the body coat plaster. Reinforcement mesh must be embedded into this. The top coat plaster is then applied with an even thickness. The top coat plaster can be rubbed, smoothed or sponged. The adhesion of all plaster layers to each other is to be ensured. Sufficient plaster adhesion can be checked on the site.[17]

In addition, observe the manufacturer's specifications, DIN 18947:2013-08, the Clay Construction Guidelines (*Lehmbauregeln*) and the Technical bulletin Requirements for clay plasters *(Technisches Merkblatt Anforderungen an Lehmputze*) by the Dachverband Lehm e. V. and the professional practice for processing lime plasters.

6.3 Finishes made from boards, cladding and membranes

Straw-insulated external walls and roof surfaces can also be finished with boards, cladding or membranes. On their own or in combination, they must be air-tight and/or wind-tight, sufficiently breathable on the outside and feature back-ventilated cladding.

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[16] See *Technisches Merkblatt Anforderungen an Lehmputze*, 2009 (Technical bulletin Requirements for clay plasters), 2009.

[17] The French straw building regulations describe plaster adhesion tests which can be carried out on site (*Règles professionelles, Annexe 3*). See also Ehlers, 2012.

Unlike plaster finish which is applied wet, boards, cladding and membranes do not fully follow the contours and adapt to the straw insulation without leaving any gaps. Where the straw makes contact with these on the outside, condensation may temporarily form in any cavities after temperature changes. The finish must be able to absorb this and transport it away. Therefore, regardless of the level of breathability, no facade/facing or roofing membranes should be used directly against the straw insulation on the external side.

7 ADDITIONAL DOCUMENTS

7.1 ETA-017/247 Building Straw

The recognition of straw bale building according to the building regulations in Germany is based on the European Technical Assessment 017/247 Building Straw. This sets out the properties, such as thermal conductivity and normal flammability. Annex B also comprehensively specifies suitable construction components.

7.2 Leaflet Instructions on processing Building Straw

These instructions define the proper processing of Building straw bales.

7.3 General Building Inspectorate Test Certificate, its update and an expert opinion

In these three documents, construction components are specified with approved fire protection properties. The General Building Inspectorate Test Certificate (*allgemeines bauaufsichtliches Prüfzeugnis*) from 2014 expired in 2019, but was updated and is now applicable until 2024. An expert opinion also specifies deviations relating to the construction components of this certificate which have been deemed not significant.

7.4 EPD

The Environmental product declaration for Building Straw (Abbreviation: EPD) allows for a life cycle assessment (LCA) of straw-insulated buildings.

7.5 “Straw-insulated buildings” brochure

The “Straw-insulated buildings” brochure published by the Fachagentur Nachwachsende Rohstoffe e. V. provides comprehensive information about all aspects of building with straw. Amongst other things, it includes an environmental assessment of a straw-insulated building in comparison to other construction methods. This section is available in English, see the annex.

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9 ANNEXES

- **Fachagentur Nachwachsende Rohstoffe e. V. (Ed.): Straw insulated buildings, Chapter 2: Building with straw is particularly sustainable. 2017**
- **ETA-17/0247 Baustroh (Building Straw), European Technical Assessment thermal insulation made from straw bales.**
- **Leaflet Instructions on processing Building Straw**
- **P-3048/817/08-MPA BS. General Building Inspectorate Test Certificate. Load-bearing, enclosing wall construction of fire-resistance class F 30 or F 90. English translation. Braunschweig: iBMB TU Braunschweig. 8.12.2014.**
- **Meyerhoff, C.: Expert opinion GA-2018-28, English translation, 2018.**

Building with straw is particularly sustainable:

ecological comparison of different building methods

Chapter 2 of the brochure “Straw insulated buildings”

Original title in German Language:

Bauen mit Stroh ist besonders nachhaltig:

ökologischer Vergleich verschiedener Bauweisen,

Kapitel 2 der Broschüre „Strohgedämmte Gebäude“

This translation is part of the UP STRAW project, supported by the Interreg programme of the European Union

Building with straw is particularly sustainable: ecological comparison of different building methods

Chapter 2 of the brochure “Straw insulated buildings”

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Building with straw is particularly sustainable: ecological comparison of different building methods

Buildings can be constructed in a particularly sustainable manner using straw bales. The advantages to this extend across all three areas of sustainability - the ecological, social and economic: Straw-insulated wood components have very few harmful effects during production. From a climate protection point of view, they even have environmental advantages because they remove climate-damaging CO_2 from the atmosphere during their lifespan in the form of carbon stored in plants. Straw-insulated components have a similar lifespan to conventional building components. They do not show any relevant differences in their manufacturing costs[1] or their costs over the entire life cycle.

1.1 Methodology

In Germany, the assessment of building sustainability is essentially carried out by two sources: For buildings in the private sector, this is primarily carried out by the German Sustainable Building Council (DGNB), while the assessment system for federal buildings (BNB) applies to the public sector.

Ecologically optimised building with straw-insulated exterior walls and roof areas is compared with three conventional construction methods. The LCA (life cycle assessment) is based on DIN EN ISO 14040 and DIN EN ISO 14044, and is similar to the methodology of the BNB and DGNB who use construction material data from the ÖKOBAUDAT 2016.[2] This is the first database in Germany to also contain precise manufacturer information. For construction straw, these have been incorporated into a standard-compliant and representative environmental product

[1] Life cycle costs according to BNB 2011 show differences between the construction methods considered of max. €100/(m^2 NGF·a) over the usual period of 50 years.

[2] Construction material data, life cycle phases and modules pursuant to DIN 15978.

declaration (EPD).[3] The list was completed with the help of the website of the Federal Office for Building and Regional Planning: www.bauteileditor.de. In the context of this pamphlet, the documentation differs from the standard in its reduced scope. The comparative LCA shown here is intended to representatively illustrate the basic differences in the construction methods using examples and selected parameters.

The production and use phases are compared with modules A1-3 and B2 and B3. The disposal phase and recycling potential are not taken into consideration in the following because primarily the effects that are directly related to the construction are to be considered.[4]

All of the buildings are the same size and have identical building technology. The components have the same masses and each have almost identical U values (+/- 0.005 W/(m²·K)). In many areas, a further, more diverse variant component formation was dispensed with. (Strip foundations, perimeter insulation, sealing the base and roofing are covered in detail, but are the same for all four construction methods).

The life cycle analysis looks at the first 50 years of the building with all the necessary maintenance, repairs and energy to meet the heating requirements.

1.2 Component variants

In addition to roof and external wall components, other components have also been included to show as many typical buildings available on the market as possible. The differences in environmental impacts (here, for example, the global warming potential) and use of resources (here, for example, the non-renewable primary energy consumption) can therefore be attributed to various parameters.

In addition to components with construction straw, other components vary.

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[3] Download the construction straw EPD at www.fasba.de or www.baustroh.de under Service/Downloads.

[4] In the disposal phase (modules C1-4), renewable raw materials emit the stored carbon dioxide during the usual thermal utilisation. Here, however, and in the recycling potential (module D) there is a large quantity of renewable energy produced, which in turn can replace fossil fuels.

Component variants, simplified representation

Components	TCS	TCC	TCM	MC
Foundation	Reinforced concrete strip foundations with 60 mm perimeter insulation			
Floor *U = 0.21*	Concrete on gravel, cellulose-insulated wooden floor	Reinforced concrete floor, cellulose-insulated wooden floor	Reinforced concrete floor, EPS insulation, screed, tiles	Reinforced concrete floor, EPS insulation, screed, tiles
Exterior walls, *U = 0.15*	Plank studding, straw insulation, clay plaster inside with dispersion paint, lime plaster outside, hydrophobic. Facade paint.	Plank studding, blown-in cellulose, OSB, gypsum fibreboard with dispersion paint, wood fibre insulation board with thin plaster, hydrophobic. Facade paint	Plank studding, mineral fibre insulation, OSB, gypsum fibreboard with dispersion paint, wood fibre insulation board with thin plaster, hydrophobic. Facade paint	2-shell masonry, sand-lime brick inside, mineral fibre insulation, facing brick
Internal walls	Wood beam, cellulose insulation, wooden framework, clay plaster, dispersion paint	Wood beam, cellulose insulation, gypsum fibreboards, dispersion paint	Metal supports, mineral fibre insulation, gypsum fibreboards, dispersion paint	11.5 cm sand-lime brick, plaster, dispersion paint
Ceiling	Open wood-beamed ceiling, tongue + groove planking, gravel, wood fibre sound insulation, wooden floor	Open wood-beamed ceiling, 3 laminated panels, gravel, wood fibre sound insulation, wooden floor	Open wood-beamed ceiling, OSB panel, gravel, mineral fibre sound insulation, wooden floor	Reinforced concrete floor, reinforced concrete ceiling, mineral fibre sound insulation. Screed, tile
Roof, *U = 0.15*	Rafter roof, roofing tiles, wood fibre roof insulating board, straw insulation, timber framework, clay plaster, dispersion paint	Rafter roof, roofing tiles, wood fibre roof insulating board, cellulose insulation, vapour barrier, counter lathing, gypsum fibre, dispersion paint	Rafter roof, roofing tiles, wood fibre roof insulating board, mineral fibre insulation, vapour barrier, counter lathing, gypsum fibre, dispersion paint	Rafter roof, roofing tiles, wood fibre roof insulating board, mineral fibre insulation, vapour barrier, counter lathing, gypsum fibre, dispersion paint
Window *Uw = 0.91*	Wooden windows triple glazed	Wooden windows triple glazed	Wooden windows triple glazed	PVC windows triple glazed
Building technology	Pellet boiler, thermal solar system, ventilation system with heat recovery, standard radiators, copper heating pipes			

Key:

TCS: Straw-insulated, plastered wooden construction

TCC: Cellulose-insulated, plastered wooden construction

TCM: Mineral fibre-insulated, plastered wooden construction

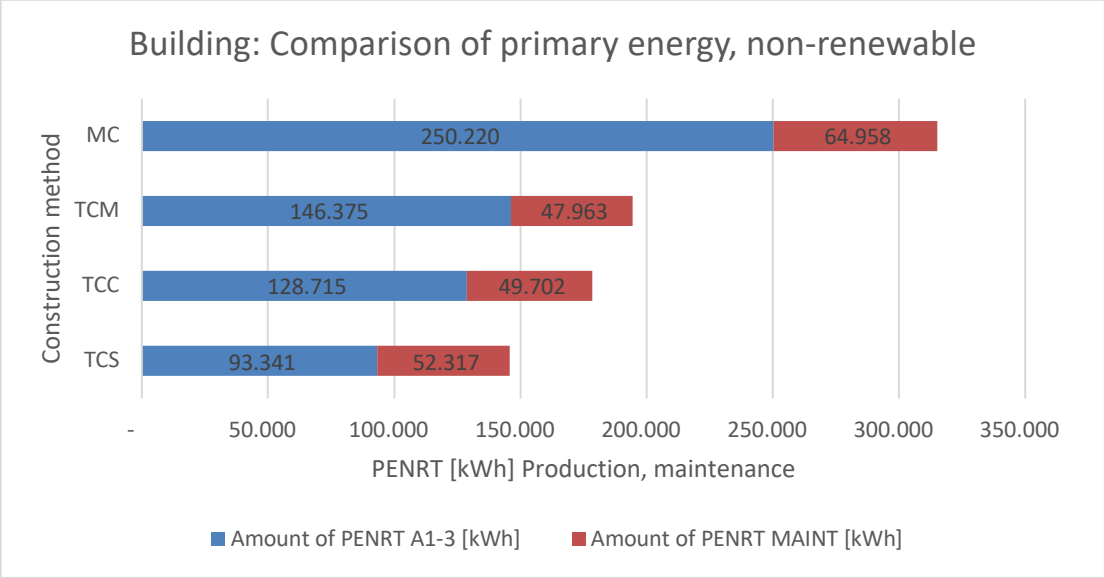
MC: Masonry construction with mineral fibre insulation, facing bricks and inner shell of sand-lime brick.

1.3 Environmental effects and use of resources

1.3.1 Manufacture (A1-3), maintenance, repair (B2-3)

Primary energy non-renewable, total (PENRT)

The straw-insulated building requires only about half of the *primary energy non-renewable (PENRT [kWh])* compared to the amount required for a conventional solid construction. The non-renewable primary energy expenditure for the manufacture, maintenance and repair of the four building types (145,658 kWh to 315,178 kWh) corresponds to heat supply (annual PENRT of 2,447 kWh) of between 60 years (straw construction) and 129 years (solid construction). A straw-insulated building can therefore be built for the same manufacture, maintenance and repair costs of the solid construction and can be supplied with heat for 69 years (see table for selected building technology).



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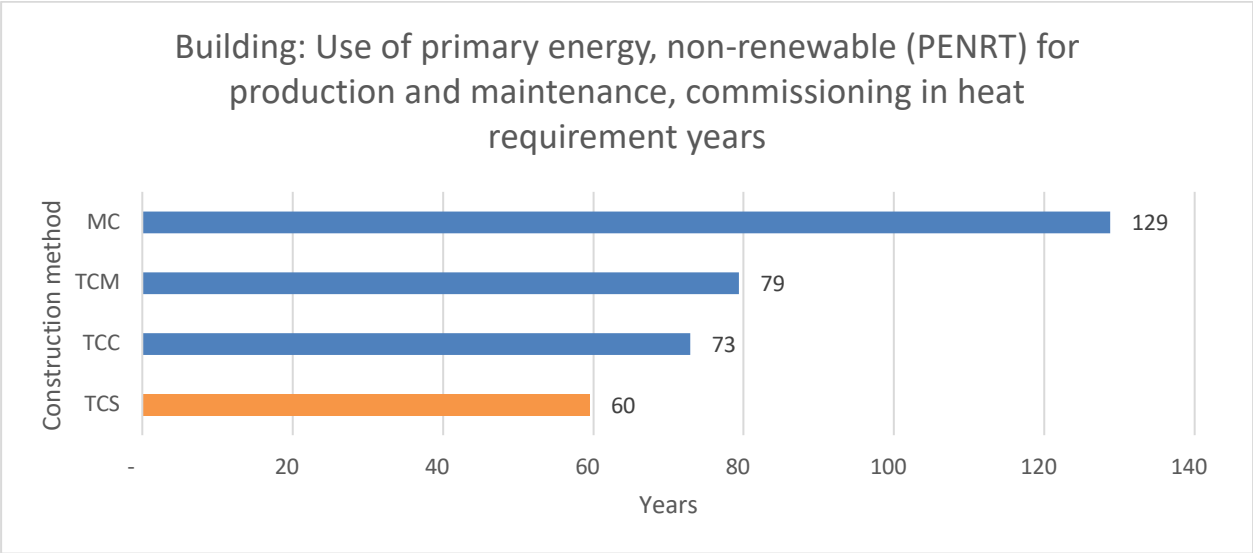

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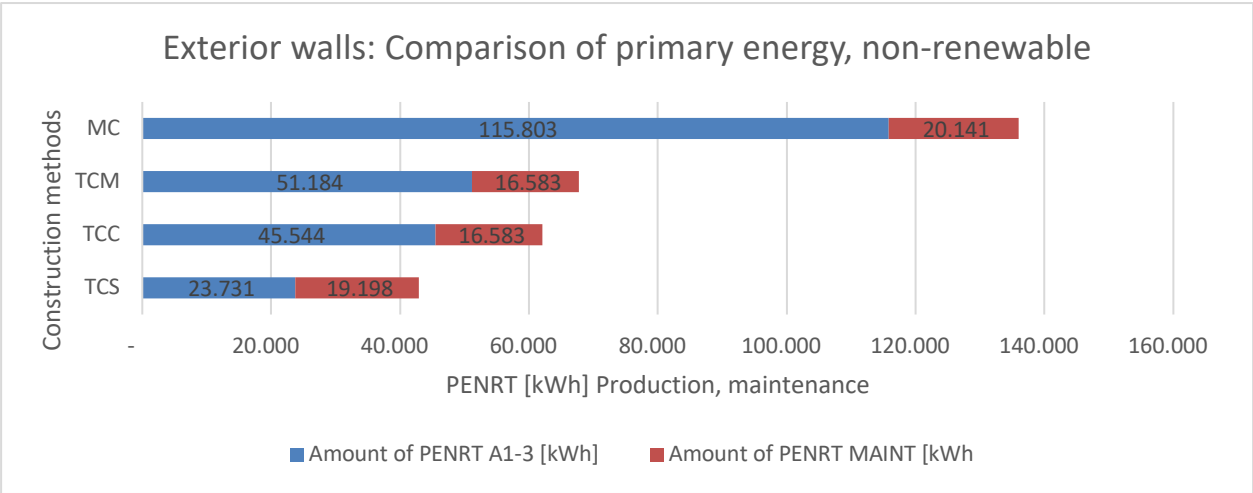
For the building construction variants, the outer wall is particularly relevant. When comparing the various outer walls, the advantages of an ecologically optimised construction become very clear. Even the difference in the non-renewable primary energy for outer walls for modules A1-3 and B2-3 (93,014 kWh) corresponds to the balanced building's heat requirement for 38 years.



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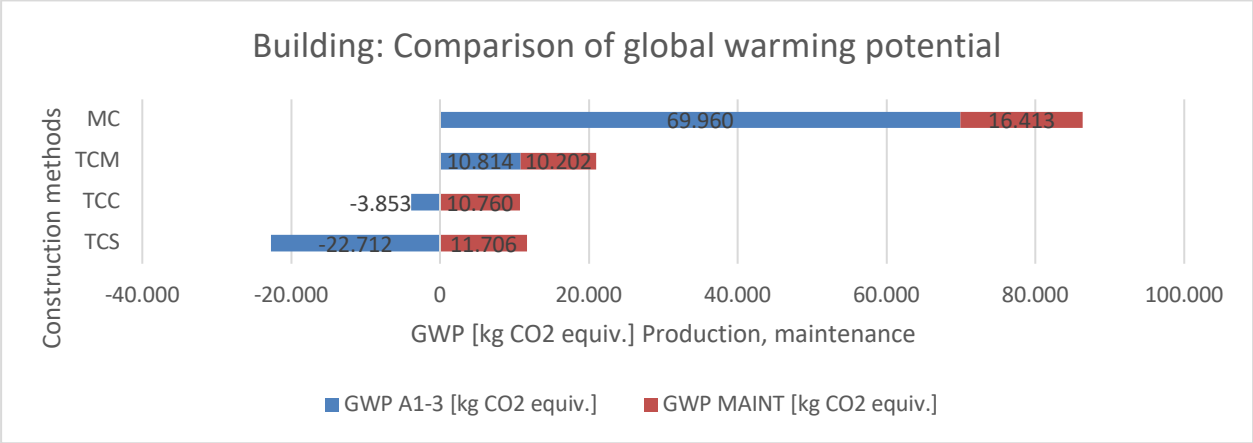
In a further comparison of the outer wall, which is particularly relevant for the variations in construction methods, it is impressively evident: The difference in global warming potential for modules A1-3 and B 2-3 (43,387 kg CO_2 equiv.) corresponds to driving 361,500 km in a fuel-efficient 5L mid-range car.

Global warming potential (GWP [kg CO_2-equiv.])



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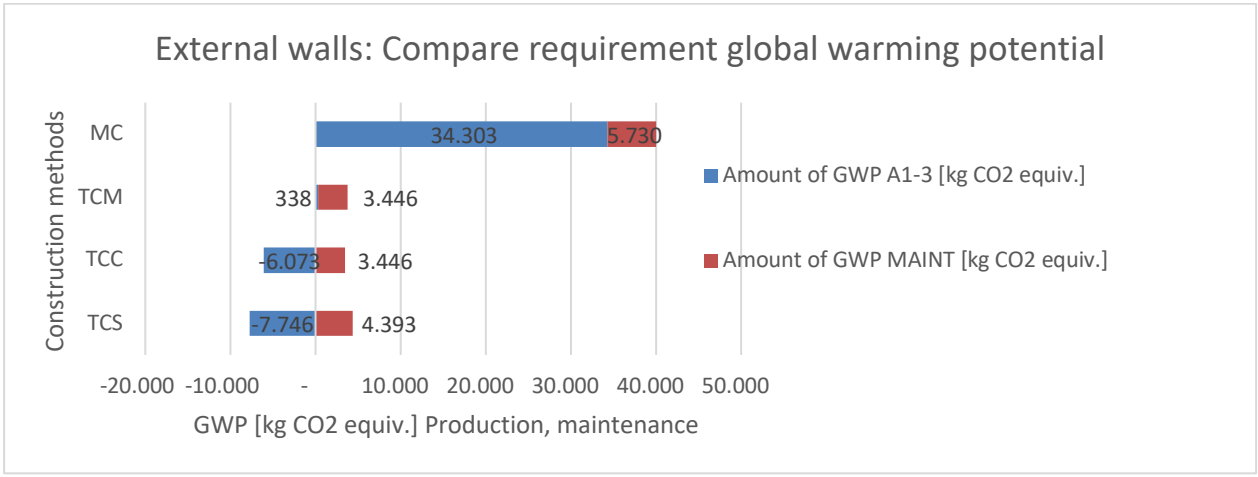
The difference between the solid construction and the ecologically optimised straw construction's global warming potential is approx. 97t CO_2 equivalent. A fuel-efficient 5L mid-range car can cover around 811,000 km before it has the same effect on the climate - this is roughly equivalent to driving around the world 20 times.



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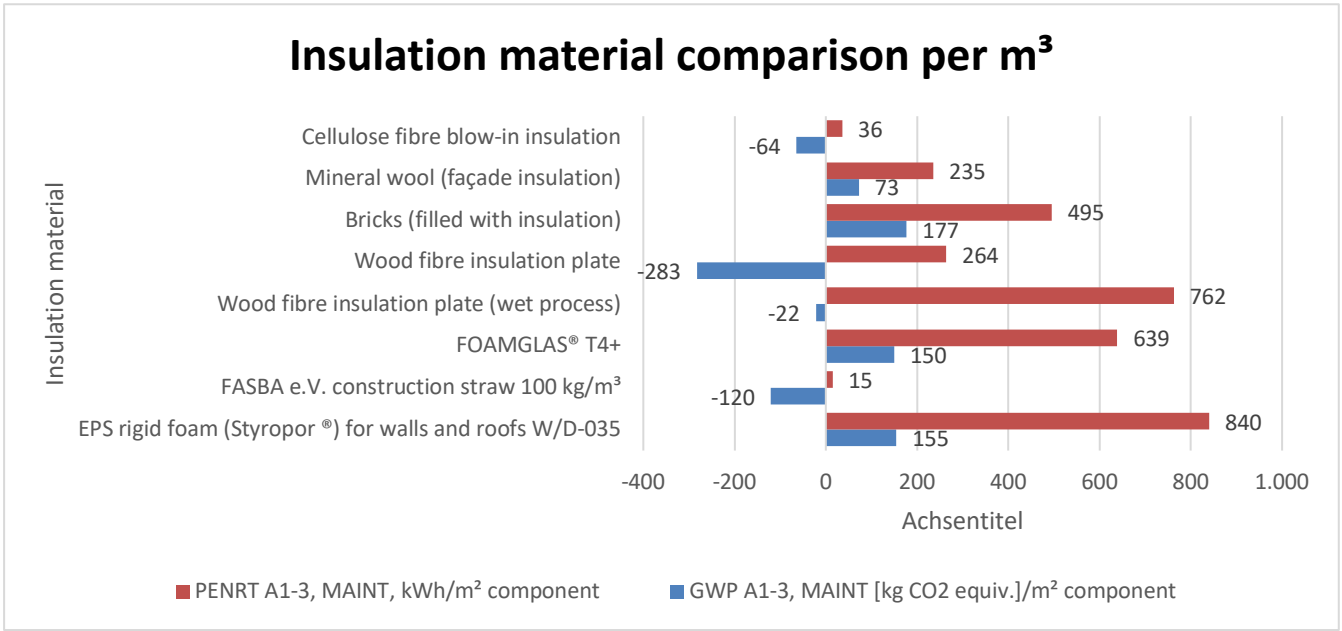

Manufacture of the finished “construction straw” insulation material results in far fewer emissions than other insulation materials and requires significantly lower manufacturing energy. It is produced almost “incidentally” as part of the agricultural harvesting process that would take place anyway. Due to the nationwide growth of grain crops, the transport distances would also be significantly reduced.

1.3.2 Service life

The non-renewable primary energy expenditure for the heat required by the same building model for all four construction types is 122,368 kWh for the 50-year period. Due to the relatively short service life of the building technology (25 years) and the associated high replacement costs, this makes up a high proportion of the environmental impact and non-renewable primary energy expenditure.

Deutsches Institut für Bautechnik

DIBt

Member of EOTA
www.eota.eu

Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

Designated according to Article 29 of Regulation (EU) No 305/2011 and member of EOTA (European Organisation for Technical Assessment)

European Technical Assessment

ETA-17/0247 of 21 June 2017

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	"Baustroh"
Product family to which the construction product belongs	Thermal insulation made of straw bales
Manufacturer	BauStroh GmbH Artilleriestraße 6 27283 Verden DEUTSCHLAND
Manufacturing plant	BauStroh GmbH Artilleriestraße 6 27283 Verden DEUTSCHLAND
This European Technical Assessment contains	7 pages including 2 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	European Assessment Document (EAD) 040146-00-1201

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This European Technical Assessment may be withdrawn by the issuing Technical Assessment Body, in particular pursuant to information by the Commission according to Article 25 Paragraph 3 of Regulation (EU) No 305/2011.

Specific part

1 Technical description of the product

This European Technical Assessment applies to the insulation product "Baustroh" made from pressed straw to bales with all blades of straw oriented in one direction.

The insulation product is initially manufactured as raw bales through baling on the field during harvesting of the crop; then the raw bales are processed on site through trained experts.

No additives are added to the insulation product in the manufacturing process.

The European Technical Assessment has been issued for the products on the basis of agreed data/information deposited with Deutsches Institut für Bautechnik, which identifies the product that has been assessed. The European Technical Assessment applies only to products corresponding to this agreed data/information.

2 Specification of the intended use in accordance with the applicable European Assessment Document

The insulation product is incorporated in a load-bearing or a non-load-bearing exterior wall structure or between rafters with a support spacing of less than one metre inside clear width.

The insulation product is not resistant to compressive loads and does not contribute to the structural stability of construction works or parts thereof.

The performance according to section 3 only applies if the insulation product is installed according to the manufacture's installation instructions and according to annex A and if it is protected from precipitation, wetting or weathering in built-in state and during transport, storage and installation.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the insulation product of at least 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the manufacturer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

For sampling, conditioning and testing the provisions of the EAD No 040146-00-1201 "thermal insulation for buildings made of straw bales" apply.

3.1 Mechanical resistance and stability (BWR 1)

Not applicable.

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire test acc. to EN ISO 11925-2:2010	Class E acc. to EN 13501-1:2007 + A1:2009

3.3 Hygiene, health and the environment (BWR 3)

Essential characteristic	Performance
Resistance to fungal growth test acc. to EAD, Annex A	No performance assessed.

3.4 Safety and accessibility (BWR 4)

Not applicable.

3.5 Protection against noise (BWR 5)

Not applicable.

3.6 Energy economy and heat retention (BWR 6)

Essential characteristic	Performance
Thermal conductivity test acc. to EN 12667:2001 (see EAD Annex B) 90° to stalk orientation (direction of thickness corresponding to alignment of stalks during installation) Declared value of thermal conductivity (see EAD Annex B) mass-related moisture content (at 23 °C / 80% relative humidity) mass-related moisture conversion coefficient moisture conversion factor (mass-related)	$\lambda_{10,dry,90/90}$ = 0.043 W/(m·K) [a)] $\lambda_{D\ (23/50)}$ = 0.048 W/(m·K) [b)] u = 11.8% $f_{u\ (dry-23/80)}$ = 0.823 $F_{m\ (dry-23/80)}$ = 1.10
Water vapour diffusion resistance factor test acc. to EN 12086:2013, climate conditions A	μ = 2.0
Specific airflow resistivity (per unit length)	No performance assessed.
Hygroscopic sorption properties test acc. to EN ISO 12571:2013 - Sorption curve - Desorption curve	Moisture absorption ≤ 18% (by mass) at 23 °C / 80% relative humidity - No performance assessed. - No performance assessed.
Water absorption (short-term by partial immersion)	No performance assessed.
Nominal length test in line with EN 822:2013	500 to 3000 mm
Nominal width test in line with EN 822:2013	300 to 900 mm
Nominal thickness (90° to stalk longitudinal axis) test in line with EN 823:2013 (with a load of 1000 Pa) dimensional deviation	200 to 700 mm ± 20 mm

Essential characteristic	Performance
Density test acc. to EN 1602:2013 (after conditioning / storage under normal climate conditions 23 °C / 50%)	100 kg/m³ ± 15 kg/m³
Dimensional stability	No performance assessed.
Tensile strength of the cording	No performance assessed.

a) Thermal conductivity of the insulation product at a reference temperature of 10 °C (dry), representative of at least 90% of the production with a 90% confidence level.
b) Declared value of thermal conductivity for a moisture content of the insulation product at 23 °C/50% relative humidity, representative of at least 90% of production with a 90% confidence level.

3.7 Sustainable use of natural resources (BWR 7)

Not applicable.

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

In accordance with the European Assessment Document No 040146-00-1201 "thermal insulation for buildings made of straw bales" the legal basis is: Commission Decision 1999/91/EC.

The system to be applied is: system 3.

In addition, the European legal basis for reaction to fire for products covered by this EAD is: Commission Decision 2001/596/EC.

The systems to be applied are: system 1, 3 or 4.

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

The technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 21 June 2017 by Deutsches Institut für Bautechnik

Prof. Gunter Hoppe
Head of Department

beglaubigt:
Getzlaff

ANNEX A

The given performances for the insulation product in clause 3 apply, if the following is taken into account regarding the installation and use:

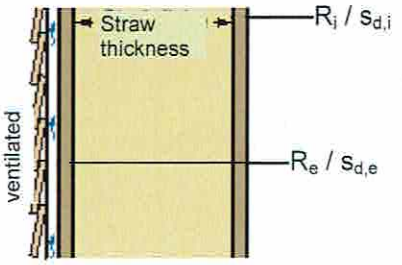
1. The insulation product is only installed in structures in which it is protected from precipitation, weathering and moisture.
2. The insulation product is installed in dry condition (moisture content $u \leq 18\%$ by mass).
3. The moisture content of the installed timber components does not exceed $u \leq 20\%$ by mass at the time when the room-facing side is closed.
4. The structure is designed in a way that the inner room-side cladding has permanently tight joints so that no flowing air can pass from the inside outwards into the structure.
5. The insulation product is installed such that the stalks are aligned at a right angle to the heat flow (90° to thickness direction).
6. All elements are planned and executed such that no mould growth can occur in the insulation.
7. The suitability of the structure for protecting from condensation and resisting mould growth is verified through simulation (e.g. based on EN 15026) for the concrete element configuration and the climate conditions at the location of installation. For the climate conditions in Germany, suitability can be assumed when the superstructure specifications in Annex B are adhered to.
8. The density of the installed thermal insulation layer is determined by the installer who issues a certificate confirming that it corresponds to the density specified in clause 3.
9. The thickness of the installed thermal insulation layer is determined by the installer who issues a certificate confirming that it at least corresponds to the required nominal thickness (planned thickness).

Annex B

Allowable moisture-dependent layer properties for structures with straw as thermal insulation in Germany

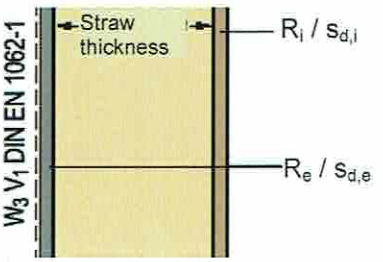
a) Exterior wall structures with back-ventilated external cladding for weather protection

Line	Straw thickness [m]	$s_{d,i}$ [m]	R_i [m²·K/W]	$s_{d,e}$ [m]	R_e [m²·K/W]
1	≤ 1.00	**≥ 0.10**	**≤ 0.35**	**≤ 0.50**	-
2	≤ 0.48	**≥ 0.76**	≤ 3.14	≤ 0.50	-
3	≤ 0.48	≥ 0.10	≤ 0.35	≤ 1.00	**≥ 1.00**
4	≤ 0.48	**≥ 2.00**	≤ 0.35	≤ 1.50	**≥ 0.70**
5	≤ 0.48	≥ 0.10	≤ 0.35	≤ 1.50	**≥ 1.43**
6	≤ 0.48	≥ 0.10	≤ 0.35	≤ 2.00	**≥ 1.90**



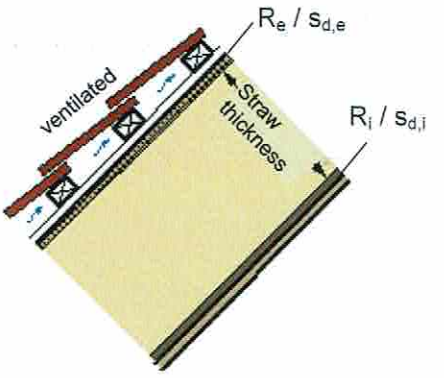
b) Plastered exterior wall structures with no weather protection
Plaster in accordance with EN 998-1 with water-repellent coating in accordance with EN 1062-1 in W_3 and V_1

Line	Straw thickness [m]	$s_{d,i}$ [m]	R_i [m²·K/W]	$s_{d,e}$ [m]	R_e [m²·K/W]
1	≤ 0.70	**≥ 0.10**	**≤ 0.35**	**≤ 0.50**	-
2	≤ 0.48	**≥ 0.76**	≤ 3.14	≤ 0.50	-
3	≤ 0.48	**≥ 3.00**	≤ 0.35	≤ 1.50	**≥ 0.30**



c) Roof structures with ventilated roofing

Line	Straw thickness [m]	$s_{d,i}$ [m]	R_i [m²·K/W]	$s_{d,e}$ [m]	R_e [m²·K/W]
1	≤ 0.48	**≥ 2.00**	**≤ 0.35**	**≤ 0.50**	**≥ 0.14**
2	**≤ 0.36**	**≥ $s_{d,e}$**	≤ 0.35	≤ 3.00	≥ 0.14



Note:
Line 1 characterises the allowable basic version.
Additional lines: possible versions with modified element characteristics (with grey background) which in turn require modified layer characteristics (values shown in bold).

Symbols, indices:
$s_{d,e}$ diffusion-equivalent air layer thickness for the external layers / cladding
$s_{d,i}$ diffusion-equivalent air layer thickness for the internal layers / cladding
R_i thermal resistance for the internal layers / cladding
R_e thermal resistance for the external layers / cladding
W_3 water permeability of coating classified acc. to EN 1062-1 and tested acc. to EN 1062-3: $W_{24} \leq 0.1$ kg/(m²·√h); Index 24 = test duration of 24 h
V_1 water vapour flux density of coating classified acc. to EN 1062-1 and tested acc. to EN 1062-3: $V_1 > 150$ g/(m²·d) with $s_d < 0.14$ m

Leaflet Instructions on processing Building straw according to European Technical Assessment ETA-17/0247

-as of October 28, 2019-

Publisher: BauStroh GmbH, Artilleriestr. 6, 27283 Verden,
www.baustroh.de info@baustroh.de

1 General information

This leaflet describes the processing of the thermal insulation material Building straw. The properties and scope of application are defined in the European Technical Assessment ETA-17/0247 of the German Institute for Structural Engeneering (DIBt). Furthermore, the declaration of performance for Building straw and the information on processing in the Straw Bale Building Guidelines must be observed. The above documents are available on our website: www.baustroh.de/downloads

1.1 The building material

Building straw is a thermal insulation material made of pure cereal straw. Building straw remains untreated after harvesting and does not contain any additives.
Building straw is golden yellow to pale yellow and is delivered dry with a maximum of 18 % by mass.
Building straw is compact. The bales are cuboid. The bulk density as a built-in thermal insulation layer must be 100 ± 15 kg/m³. Properly installed, they fill in a frame evenly compressed, without any gaps and with no possibility of settlement.

1.2 Properties of Building straw

Declared value of thermal conductivity $\lambda_{D\ (23/50)}$ according to EN 12667:2001 perpendicular to the direction of the stalk	0.048 W/(m·K)
Density at normal climate 23°C/50% rel. humidity according to EN 1602:2013 100 ± 15 kg/m^3	100 ± 15 kg/m^3
Vapour diffusion resistance factor according to EN 12086:2013, climatic conditions A	μ = 2,0
Moisture absorption at 23°C and 80% rel. humidity according to EN ISO 12571:2013	≤18 % by mass
Fire behaviour according to EN 13501-1:2007 + A1:2009	class E (normal flammability)

The declared value of thermal conductivity applies exclusively to the predominantly vertical orientation of the stalks, i.e. in walls only for upright and upright straw bales, i.e. the strings of the bales are visible after installation.
Bales of straw with stalks oriented in the direction of the heat flow (e.g. lying flat in walls) do not comply with the European Technical Assessment.

1.3 Area of application

Building straw is used as infilling thermal insulation in a load-bearing or non-load-bearing external wall constructions, roofs (between rafters) and top-floor ceilings.
Building straw must not be subject to pressure and must not take over any tasks of stability of the building or its parts.

Building straw is installed with a support spacing of less than one metre inside clear width. Surfaces of Building straw can be plastered directly.
Building straw can be used both in new buildings and in the renovation of existing buildings. Allowable construction components with Building straw are listed in Appendix B "Allowable moisture-dependent layer properties for structures with straw as thermal insulation in Germany " of the European Technical Assessment ETA-17/0247 with their areas of application.

2 Requirements for the installation of Building straw

2.1 Bale dimensions and frame sizes

Support spacing and wall thicknesses must match the dimensions of the straw bales. Therefore, the bale format must be known in good time and the planning must be based on an appropriate grid dimension.

2.2 Determining the suitable clear width of the frames

When installing the bales horizontal on edge (the strings of the bales after installation are visibly vertical) in walls, the frame width is determined by the width of the bale. When installing the bales vertical on edge (the strings of the bales after installation are visibly horizontal), the bales' lengths, which vary by approximately +/- 5 cm due to production, cannot correspond to a certain frame width.
Bales can be installed horizontal on edge, either individually or two by two. The clear frame width then results from the single bale width or the double bale width. When doubling so-called small or high-density bales, the required support spacing of less than one metre in the clear width is maintained.
For straw insulated ceilings and roofs, the above instructions apply analogously.

A rule of thumb for determining the suitable frame width may be considered:
- one bale horizontal on edge per frame: clear frame width = bale width - 1cm
- two bales horizontal on edge per frame: clear frame width = 2 bale widths - 2cm

2.3 Quantity determination, delivery and storage

The required amount of Building straw is calculated exactly from the total area of all the frames to be filled with Building straw without the wood parts of the frame plus the necessary compression during installation and a waste surcharge of 5%. In case of numerous deviations from the straw bale grid, this surcharge should be increased.

To simplify matters roughly, the quantity can also be determined: Total area of all frames including wood parts of the frame + 5%.

Building straw must always be kept dry. This applies to transport, storage and during the construction phase and installation. Immediately after installation, straw surfaces endangered by driving rain must be covered e.g. with tarpaulins or similar.

3 Infill with Building straw

3.1 Straw installation

Building straw must be installed so that the strings of the bales on the long sides is visible on the straw surface after installation. Only then are the stalks predominantly aligned perpendicular to the heat flow, and only then does the declared value of thermal conductivity of λD (23/50) = 0.048 W/(m·K) apply.

In order to ensure a level infilling, the bales are compressed during installation.

After installation, Building straw must sit tightly, without gaps and with no possibility of settlement in the frame.
The density of the delivered bales is stated on the delivery note at 23°C and 50% relative humidity. The density required in the European Technical Assessment ETA-17/0247 for Building straw under 3.6 is 100 ± 15 kg/m3 when installed at 23°C and 50% relative humidity. In order to achieve this, the delivery note indicates the necessary compression during installation.

If the frame width corresponds to two straw bale widths, the bales are placed in pairs on the frame edges at an angle to each other and then pressed completely into the frame.
Both in pairs and single installation is carried out with physical exertion, with insertion aids (flat plates made of sheet metal or wood-based material) and with a straw hammer (with long handle and larger head made of wood) or similar.
The required height of the first or last straw bale layer is calculated from the frame height plus compression minus the height of all other straw bale layers. This layer must usually be produced separately in length. Straw bales can be shortened with bale needles. They are pushed through the straw bale according to the desired length next to the original strings, the new strings are pulled through each time and tied around the bale. The compression is thus maintained. Then the original strings are loosened, loose straw falls off and the shortened bale remains.
Before the last layer of straw is inserted, the straw that has already been placed in the frame is compressed. This can be done with tension belts or chain hoists. As soon as the necessary compression has created sufficient space for the insertion of the last bale layer, this layer is inserted. The tension is then released and the straw infill lies tightly against the joints.

Installation is possible in vertical, horizontal and roof areas, both in prefabrication and at the construction site.

Other compression techniques are possible.

In the case of highly compressed straw bales, uniform infilling can also be achieved by decompression. This is possible with straw bales of high density.
The bales are installed as tightly as practically possible. Here too, the length of the last layer of straw bales is adjusted as described above. The strings are then released. The subsequent expansion of the straw bales results in a complete and uniform infilling. Experience shows that the better installation qualities can be achieved by means of compression.

After the bales have been installed, any hollow areas must be stuffed with straw in such a way that the weight of the plaster does not cause straw to be pulled out during subsequent plastering.

3.2 Production of even straw surfaces for later finishing

After installation, the straw surfaces created must be levelled out so that the finishing can be applied afterwards. Coarse unevenness must be levelled (with a straw hammer or similar). Then the straw surfaces must be cut back and levelled. Chain saws, hedge trimmers, brushcutters, etc. are suitable for this.

After cutting back, the straw surface must be cleaned of loose straw particles, e.g. by means of compressed air or a broom.

4 Finishing of Building straw

Building straw is finished on the inside and outside. All finishings are suitable which comply with the specifications in Annexes A and B of the European Technical Assessment ETA-17/0247.

Surfaces of Building straw can be plastered directly. There is a leaflet on the direct plastering of Building straw. This is available on our website (German version only):
www.baustroh.de/downloads

Institute for Building Materials, Solid Construction and Fire Protection

Material Testing Institute for the Construction Industry

General Building Inspectorate Test Certificate

Test certificate number: P-3048/817/08-MPA BS

Object: Load-bearing, enclosing wall construction of fire-resistance class F 30 or F 90 pursuant to DIN 4102 - 2 : 1977-09 for one-sided fire exposure in accordance with no. 2.1 Building Regulations List A Part 3 - edition 2014/1 Designs for the construction of load-bearing walls subject to requirements regarding the period of fire-resistance

Applicant: Fachverband Strohballenbau Deutschland e. V.
Artilleriestraße 6
27283 Verden

Date of issue: 08/12/2014

[round stamp: MATERIAL TESTING INSTITUTE FOR THE CONSTRUCTION INDUSTRY, BRUNSWICK]

Duration of validity: 03/03/2014 to 02/03/2019

This general building inspectorate test certificate consists of 11 pages and 1 annexure.

This general building inspectorate test certificate replaces the general building inspectorate test certificate no. P-3048/817/08-MPA BS dated 24 June 2008.

This general building inspectorate test certificate no P-3048/817/08-MPA BS was first issued on 24/06/2008.

Material Testing Institute (MPA)
for the Construction Industry
Beethovenstraße 52
D-38106 Brunswick

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Notified body (0761-CPR) - Recognised and notified by building inspectorate for testing, monitoring, inspection and certification. Accredited as testing and calibrating laboratory pursuant to ISO/EC 17025, inspection authority pursuant to ISO/EC 17020 and certification authority pursuant to ISO/EC 17065.

A General Provisions

With the general building inspectorate test certificate, the applicability of the design within the meaning of the State Building Codes is attested.

The general building inspectorate test certificate does not replace any approvals, permits and certificates legally required for the implementation of a building project.

The general building inspectorate test certificate is issued irrespective of any third party rights, particularly concerning private property rights.

Manufacturers and distributors of the design must provide to users of the design a copy of the general building inspectorate test certificate, irrespective of any other regulations stated under “special provisions”. The user must keep the general building inspectorate test certificate on file.

The general building inspectorate test certificate may only be reproduced in its entirety. The publication of excerpts requires an approval of the Material Testing Institute for the Construction Industry, Brunswick. Texts and drawings of advertising materials are not allowed to contradict the general building inspectorate test certificate. Translations of the general building inspectorate test certificate must contain the note “Translation of the German original version not verified by the Material Testing Institute for the Construction Industry, Brunswick”.

The general building inspectorate test certificate may be cancelled at any time. The general building inspectorate test certificate may subsequently be amended or altered, in particular if required due to new technical findings.

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B Special Provisions

1. Object and Scope of Application

1.1. Object

1.1.1. The general building inspectorate test certificate (abP) is valid for the construction and use of load-bearing, enclosing wall constructions of fire-resistance class F 30 or F 90 for one-sided fire exposure, specification (short description) F 30-B or F 90-B, pursuant to DIN 4102-2 : 1977-09[*)].

1.1.2. The load-bearing, enclosing wall construction must consist of a timber framework filled with a heat insulating material made of strawbales “building straw” as well as clay plaster or light plaster on a lime-cement basis on both sides. Please refer to section 2 of this general building inspectorate test certificate for further details.

[*)] This general building inspectorate test certificate contains references with and without a date as well as definitions from other publications. All references are marked accordingly within the text, and the respective publications are listed on page 10. For references including a date, all subsequent amendments or revisions of such publications must be taken into consideration in relation with this general building inspectorate test certificate. For references without a date, the latest edition of the referenced publication shall be applicable.

1.2. Scope of Application

1.2.1. The framework of the wall construction must be made of solid timber with a minimum strength class of C 24 pursuant to DIN EN 338 and a sorting class of S 10 pursuant to DIN 4074-1. The dimensions of the timber columns must be w x h ≥ 60mm x 360mm. All other provisions of the technical building regulations applicable to timber constructions must be observed.

1.2.2. The load-bearing, enclosing wall construction must span from raw ceiling to raw ceiling.

1.2.3. The wall construction may be any width. The permissible height of the wall is limited to 5.0m for fire protection reasons. The slimness of the timber columns must not exceed the value of $\lambda_y = 29$ (for protruding wall angles) and the value of $\lambda_y = 173$ (for retracting wall angles).
In the event of a fire, the stress on the column profile must not exceed the value of $\sigma = F/A = 1.93$ N/mm^2.

1.2.4. The supporting and re-enforcing building components must at least have the same fire-resistance properties as the object under 1.1.

1.2.5. Power points, switches, distribution boxes, etc. may be installed directly opposite each other. Furthermore, these items are allowed to be mounted at any location. The implementation must be in accordance with section 2.2.1.4 or section 2.2.2.4.

1.2.6. Additional common paints or other coatings with a thickness of up to 0.5mm do not affect the fire-resistance rating. Additional cladding (except for sheet steel cladding) such as plaster or veneer is permissible. In case of combustible building materials, the requirements of the building inspectorate must be observed where applicable.

1.2.7. Smoke barriers (e. g. PE foil) do not affect the fire-resistance classification.

1.2.8. Electric lines are allowed to run through the enclosing wall construction where required if the resulting profile of the hole is completely filled and sealed to the width of the wall with a shape-retaining, non-combustible building material such as mortar, concrete or gypsum.

1.2.9. Barriers are required for leading through pipes, electrical lines, installation channels, cable channels or ventilation ducts, whereby their fire-resistance class must be evidenced through testing. Further proof of suitability, e. g. in the form of a general building inspectorate approval or a general building inspectorate test certificate is required.

1.2.10. If the enclosing wall construction with a certain fire-resistance class is to be fitted with glazing, fire barriers or cut-off devices of a certain fire-resistance class in order to prevent fire transmission through ventilation ducts, the suitability of these fixtures in combination with the wall construction must be evidenced through testing. Further proof of suitability, e. g. in the form of a general building inspectorate approval is required.

1.2.11. Additional requirements or simplifications may arise from the technical provisions applicable to the design (e. g. building code, special building regulations or guidelines).

1.2.12. In case of sound proofing requirements, further certification is to be provided.

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1.2.13. According to the declaration of the applicant, no products are used as part of the design that are subject to the Ordinance on Hazardous Substances, the Ordinance on Prohibited Chemicals, the Ordinance on the Prohibition of CFC and Halon, or compliance with the provisions of the above ordinances is ensured (in particular regarding labelling obligations).

Furthermore, the applicant declares that - in the event that hygiene, health or environmental protection measures are required for trading, placing on the market or use of the design - such measures were initiated or advised by the applicant as required.

As a result, there was no reason to test the effects of the building products in their installed state regarding their compliance with health and environmental protection requirements.

2. Provisions regarding the design

2.1. Characteristics and composition

The details listed in table 1 apply to building products to be used regarding their specifications, characteristic values of materials, building inspectorate classification and proof of applicability.

Table 1: Summary of characteristic values of the building products

Building product / proof of applicability	Thickness (standard size) [mm]	Gross density (nominal value) [kg/m³]	Building inspectorate classification pursuant to BRL
Construction timber cuts pursuant DIN EN 338 and DIN 4074-1	see annexure	≥ 510	normal flammability
Insulation material made of strawbales “building straw” pursuant to abZ no. Z-23.11-1595	≥ 360	85 - 115	normal flammability
Clay plaster (pre-mixed plaster without straw supplement of Claytec, Viersen pursuant DIN 18947:2013-08)	≥ 8	≥ 1600	non-combustible
Mineral base plaster “gräfix 73 Pajalith” (light plaster on lime-cement basis of Wolfgang Endress, Lime and Gravel Factory, Gräfenberg)	approx. 10	approx. 800[1)]	non-combustible

[1)] Solid mortar gross density
Acronyms used
abZ => General building inspectorate approval
abP => General building inspectorate test certificate

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The list of documents based on which the general building inspectorate test certificate was issued is kept on file by the testing institute.

2.2. Constructional design of wall construction

2.2.1. Constructional design of the load-bearing, enclosing wall construction of fire-resistance class F 30

The load-bearing, enclosing wall construction of fire-resistance class **F 30** consists of a timber framework filled with a heat insulating material made of strawbales “building straw” as well as clay plaster or light plaster on a lime-cement basis on both sides. The design must be implemented in accordance with sections 2.2.1.1 to 2.2.1.5 and Annexure 1 below.

2.2.1.1. Base construction

The wall construction consists of a timber frame construction with timber columns, bottom plate and top plate measuring w x h ≥ 60mm x 360mm.

The bottom plate and top plate are mounted to the columns with two steel screws ≥ 8 x 200mm each. Alternatively, the bottom plate and top plate may be mounted to the columns using three chipboard screws ≥ 6 x 140mm.

Steel cross braces with a thickness of ≤ 2mm are allowed to be mounted to the timber construction.

On each side of the timber columns of the framework, a timber packing block measuring w x t = 20mm x 20mm must be mounted using chipboard screws ≥ 3.5mm x 45mm, d ≤ 600mm. Alternatively, a triangular timber packing block measuring w x t = 38mm x 58mm may be arranged on either side of the timber columns and fixed to the respective timber column using chipboard screws ≥ 4.5mm x 70mm, d ≤ 600mm.

The distance between the timber columns (axial dimension) must be d ≤ 1000mm.

Insulation

The compartments between the timber columns must be filled with a heat insulating material with a total thickness of approx. 360mm made of strawbales “building straw” in accordance with the general building inspectorate approval no. Z-23.11-1595, whereby the strawbales must be arranged so that the stalks are aligned with the surface of the wall, i. e. pointing from column to column or from bottom plate to top plate.

The insulation must be secured by being tightly packed into the compartments in order not to fall out.

Any excess straw must be cut off (e. g. with a chainsaw), so that the strawbales are flush with the timber frame on either side. Any lose straw must be brushed off, so that an almost even wall surface is created on both sides of the wall.

2.2.1.2. Gaps

Any gaps between the strawbales, or between strawbales and timber components (framework, bottom plate, top plate, etc.) must be tightly stuffed with straw.

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2.2.1.3. Application of plaster

Both sides of the wall are to be plastered with

- clay plaster or

- mineral base plaster “gräfix 73 Pajalith” (light plaster on a lime-cement basis of Wolfgang Endress, Lime and Gravel Factory, Gräfenberg)

Alternatively, clay plaster can be applied to one side of the wall and mineral base plaster “gräfix 73 Pajalith” to the other side of the wall.

Prior to plastering, a 10mm thick lath of reed mats (at least normal flammability) must be mounted to cover the entire timber construction (columns, bottom plate, top plate and packing block). Thereby, the stalks of the reed mats must be joined with an intertwining steel wire positioned in a right angle to the direction of the stalks. The above tying wires must be d ≤ 100mm apart - measured along the stalks - and force-fitted to the timber construction using at least three suitable steel wire braces.

If using the mineral base plaster “gräfix 73 Pajalith”, the lath may alternatively consist of a layer of custom-sized, 9.5mm thick timber soft fibre plates (at least normal flammability) with butted up end laps mounted to the timber construction. Chipboard screws ≥ ø 4mm x 40mm are to be used to mount the timber soft fibre plates. The chipboard screws must be arranged in two rows, i. e. two screws arranged directly adjacent to one another (so-called pair assembly), whereby the distance between the screw pairs must not exceed d = 150mm measured along the timber soft fibre plate strips.

The two above plastering methods are described in the following.

Clay plaster

On the surface of the wall, clay plaster of at least t = 8mm thickness (pre-mixed plaster of the company Claytec, Viersen) must be worked into to the straw base in two layers.

Mineral base plaster “gräfix 73 Pajalith“

The mineral base plaster “gräfix 73 Pajalith” must first be applied on the straw surface in the same thickness as the lath, i. e. approx. t = 10mm thick. Then, a layer of plaster is applied on the lath, t ≥ 10mm, and the so-created plaster strip must be spread 150mm wide across the straw surface, so that in the area of the lath, a plastered surface with a thickness of at least 18mm is created. The minimum thickness of the plaster applied outside the lath area is t = 10mm.

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2.2.1.4. Fixtures

Electrical distribution boxes (e. g. power points, switches or distribution boxes) may be installed in the wall. The fixtures must be completely enclosed with a clay plaster of at least 30mm thickness (walls with clay plaster) or at least 10mm mineral base plaster “gräfix 73 Pajalith” (walls with “gräfix 73 Pajalith” - base plaster), whereby the straw in this area must be tightly compressed or removed.

2.2.1.5. Building components surrounding fittings

Fittings must be implemented in accordance with the static requirements pursuant to DIN 4102-4 : 1994-03, Section 4.12.

Please refer to Annexure 1 of this general building inspectorate test certificate for further details on the constructional design of the load-bearing, enclosing wall construction of fire-resistance class F 30.

2.2.2. Constructional design of the load-bearing, enclosing wall construction of fire-resistance class F 90

The load-bearing, enclosing wall construction of fire-resistance class **F 90** consists of a timber framework filled with a heat insulating material made of strawbales “building straw” and light plaster on a lime-cement basis on both sides. The design must be implemented in accordance with sections 2.2.2.1 to 2.2.2.5 and Annexure 1 below.

2.2.2.1. Base construction

The wall construction consists of a timber frame construction with timber columns, bottom plate and top plate measuring w x h ≥ 60mm x 360mm.

The bottom plate and top plate are mounted to the columns using three chipboard screws ≥ 6mm x 140mm.

On each side of the timber columns of the framework, a triangular timber packing block measuring w x h = 38mm x 58mm must be arranged and fixed to the respective timber column using chipboard screws ≥ 4.5mm x 70mm, d ≤ 600mm.

The distance between the timber columns (axial dimension) must be d ≤ 1000mm.

Insulation

The compartments between the timber columns must be filled with a heat insulating material with a total thickness of approx. 360mm made of strawbales “building straw” in accordance with the general building inspectorate approval no. Z-23.11-1595, whereby the building strawbales are arranged so that the stalks are aligned with the surface of the wall, i. e. pointing from column to column or from bottom plate to top plate.

The insulation must be secured by being tightly packed into the compartments in order not to fall out.

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Any excess straw must be cut off (e. g. with a chainsaw), so that the strawbales are flush with the timber frame on either side. Any lose straw must be brushed off, so that an almost even wall surface is created on both sides of the wall.

2.2.2.2. Gaps

Any gaps between the strawbales, or between strawbales and timber components (framework, bottom plate, top plate, etc.), must be tightly stuffed with straw.

2.2.2.3. Application of plaster

Both sides of the wall are to be plastered with the mineral base plaster “gräfix 73 Pajalith” (light plaster on a lime-cement basis of Wolfgang Endress, Lime and Gravel Factory, Gräfenberg).

Prior to plastering, a 10mm thick lath of reed mats (at least normal flammability) must be mounted to cover the entire timber construction (columns, bottom plate, top plate and packing block). Thereby, the stalks of the reed mats must be joined with an intertwining steel wire positioned in a right angle to the direction of the stalks. The above tying wires must be d ≤ 100mm apart - measured along the stalks - and force-fitted to the timber construction using at least three suitable steel wire braces. In addition, the reed mats must be attached in the area of each alternate tying wire using three to four chipboard screws ≥ ø 4mm x 40mm in conjunction with a washer ≥ ø 4.3mm x 20mm, so that the distance between the above-mentioned mountings is no more than d = 200mm measured along the reed stalks.

The lath may alternatively consist of a layer of custom-sized, 9.5mm thick timber soft fibre plates (at least normal flammability) with butted up end laps mounted to the timber construction. Chipboard screws ≥ ø 4mm x 40mm are used to mount the timber soft fibre plates. The chipboard screws must be arranged in two rows, i. e. two screws arranged directly adjacent to one another (so-called pair assembly), whereby the distance between the screw pairs must not exceed d = 150mm measured along the timber soft fibre plate strips.

The mineral base plaster “gräfix 73 Pajalith” must first be applied on the straw surface in the same thickness as the lath, i. e. approx. t = 10mm thick. Then, a layer of plaster is applied on the lath, t ≥ 10mm, and the so-created plaster strip must be spread 150mm wide across the straw surface, so that in the area of the lath, a closed, dense plastered surface with a thickness of at least 18mm is created. The minimum thickness of the plaster applied outside the lath area is t = 10mm.

2.2.2.4. Fixtures

Electrical distribution boxes (e. g. power points, switches or distribution boxes) may be installed in the wall. The fixtures must be completely enclosed with a mineral base plaster “gräfix 73 Pajalith” of at least 10mm, whereby the straw in this area must be tightly compressed or removed.

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2.2.2.5. Building components surrounding fittings

Fittings must be implemented in accordance with the static requirements pursuant to DIN 4102-4 : 1994-03, Section 4.12.

Please refer to Annexure 1 of this general building inspectorate test certificate for further details on the constructional design of the load-bearing, enclosing wall construction of fire-resistance class **F 90**.

3. Compliance certificate

The user of this design must confirm that the design was implemented in accordance with the provisions of the general building inspectorate test certificate and that the building products used comply with the provisions of the general building inspectorate test certificate (refer to page 11 for a compliance declaration template).

4. Provisions regarding the drafting and measurements

The drafting and measurements must be in accordance with the technical construction regulations applicable to the object under 1.1.

5. Provisions regarding the use, sustenance and maintenance

The fire protection requirements can only be consistently met if the object under 1.1 is permanently kept in a proper condition. In the event of replacement of damaged components, it must be ensured that the substitute materials and installation of such materials is in accordance with the provisions and requirements of this abP.

6. Legal basis

The general building inspectorate test certificate is issued in accordance with §19 of the Lower Saxony Building Code (NBauO) of 03 April 2012 (Lower Saxony Gazette P. 46) in conjunction with the Building Regulations List Part A of the German Institute for Building Technology, Berlin, edition 2014/1. The State Construction Codes of other states have corresponding legal provisions.

7. Instructions on the right to appeal

An appeal against this decision may be filed with the Material Testing Institute for the Construction Industry, Brunswick, within one month of its announcement.

[signed]
Grad. Eng. Mittmann
Deputy Head of the Testing Department

[signed]
Grad. Eng. Rabbe
Consultant

Brunswick, 08/12/2014

For an index of applicable standards and regulations, please refer to the following page.

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Index of Standards and Regulations

DIN EN 338:	Timber for load-bearing purposes - strength class
DIN 4074-1:	Sorting of conifer timber by load-bearing properties; sawn conifer timber
DIN 4102-2:	Fire behaviour of building materials and components; components; definitions, requirements and tests
DIN 4102-4:	Fire behaviour of building materials and components; composition and application of classified building materials, components and special components
DIN 4102-5:	Fire behaviour of building materials and components; fire barriers; definitions, requirements and tests
DIN 4102-9:	Fire behaviour of building materials and components; cable insulation; definitions, requirements and tests
DIN 4102-11:	Fire behaviour of building materials and components; pipe encasement, pipe insulation, installation shafts and channels as well as barriers for inspection openings; definitions, requirements and tests
DIN 4102-13:	Fire behaviour of building materials and components; fire protective glazing; definitions, requirements and tests
	Building Regulations List with latest amendments

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Template for
Compliance Declaration

- Name and address of company, which has constructed the load-bearing, enclosing wall construction

- Building site or premises:

- Construction date:

- Fire-resistance class F 30 or F 90 *)

It is hereby confirmed that the load-bearing, enclosing wall construction was constructed and installed in a professional manner in all aspects and complies with all the provisions of the general building inspectorate test certificate no. P-3048/817/08-MPA BS of the Material Testing Institute for the Construction Industry, Brunswick, of 08/12/2014.

The same is confirmed with respect to any building products or parts that have not been manufactured by the undersigned (e. g. ……) based on

- existing labelling of the parts in accordance with the provisions of the general building inspectorate test certificate*)
- self-conducted controls*)
- respective written confirmations of manufacturers of the building products or parts kept on file by the undersigned.*)

Place, date Stamp and signature
(This certificate must be given to the client for submission to the competent building inspectorate.)

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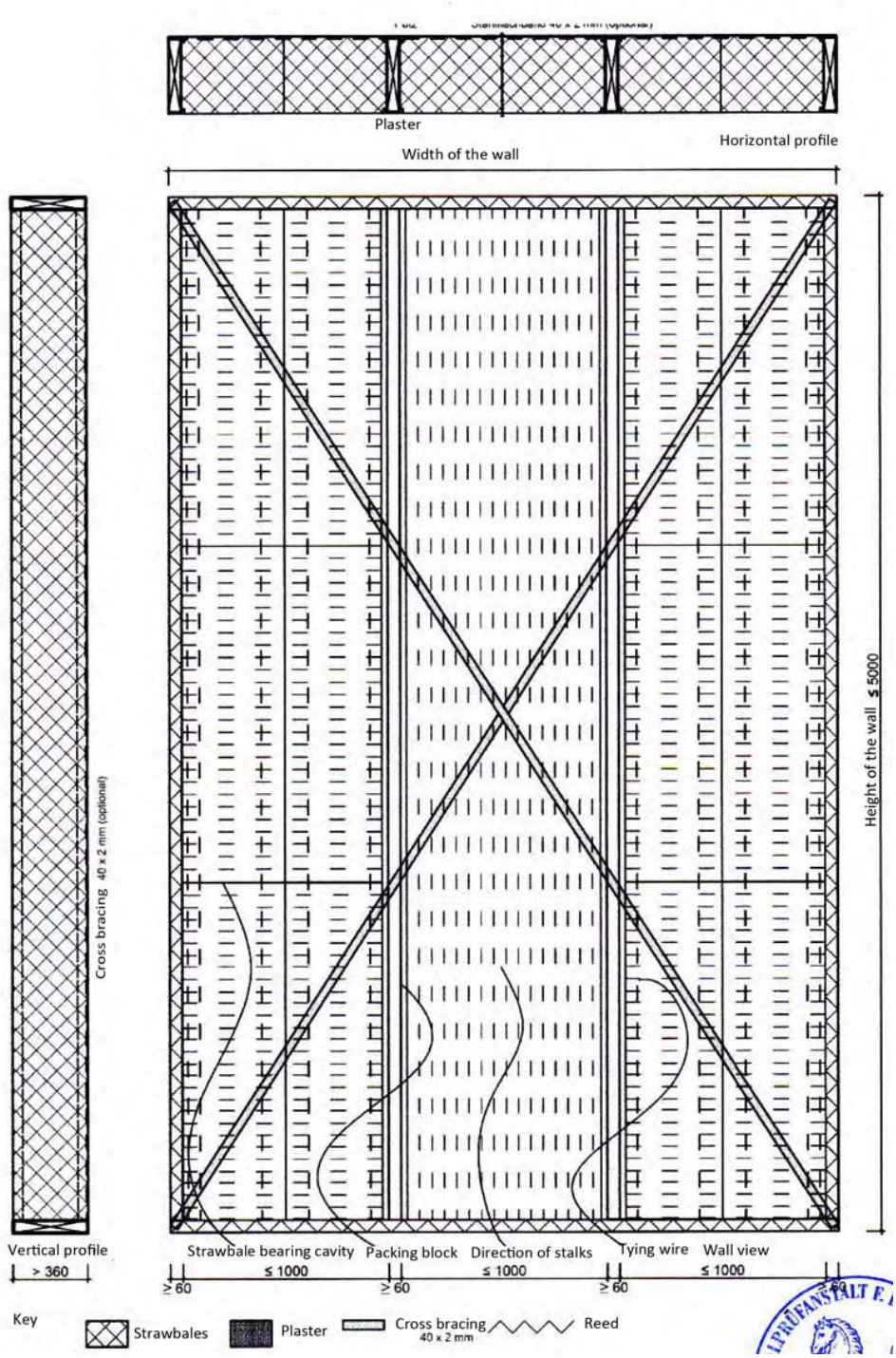
BRUNSWICK]

*) Please delete if not applicable



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Frame construction:
≥ 60/360mm columns, mounted pursuant to sections 2.2.1.1 and 2.2.2.1

Strawbales: Measurements (h x w x l) 360 x 480 x 540 - 1000mm
Fixed with packing block

Cladding:
Plaster pursuant to sections 2.2.3.4 or 2.2.2.4

Bracing:
Cross bracing 40 x 20mm (optional)

Load-bearing, enclosing wall construction of fire-resistance class F 30 or F 90 pursuant DIN 4102-2 : 1977-09 Elevation and profiles	Annexure 1 of abP No.: P-3048/817/08-MPA BS of 08/12/2014

CERTIFICATION
I, Yvonne Goldmann, NAATI accredited Professional Translator (NAATI ID 53769) hereby certify that the above English text is a true and correct translation from the German language of the document attached hereto, prepared by me to the best of my ability. Brisbane, 7 March 2017

NATIONAL ACCREDITATION AUTHORITY FOR TRANSLATORS AND INTERPRETERS LTD
NAATI No. 53769
YVONNE GOLDMANN
PROFESSIONAL TRANSLATOR
GERMAN -> ENGLISH
EXPIRES - 30/01/2019
ACCREDITATION

Expert opinion No. GA- 2018/028 - Mey dated 24/04/2018

Original title in German language:

Gutachterliche Stellungnahme Nr. GA 2018/028 – Mey vom 24.04.2018

This translation is part of the UP STRAW project, supported by the Interreg programme of the European Union

Expert opinion No. GA- 2018/028 - Mey dated 24/04/2018

English translation – Original version in German language

Client:	Fachverband Strohballenbau e.V. Artilleriestraße 6 D-27283 Verden
Order dated:	29/03/2018
Order signed by:	Ms Imhoff
Order received	29/03/2018
Order content:	General expert opinion on the fire behaviour of load-bearing, separating wall constructions in timber frame construction with a cavity insulation of construction straw in connection with various design variants based on the general building authority inspection test certificate No. P-3048/817/08-MPA BS with regard to classification as fire resistance class F 30 or F 90 according to DIN 4102-2: 1977-09 with one-sided fire exposure
Construction project:	This expert opinion only applies to construction projects in the Federal Republic of Germany

This expert opinion comprises 10 pages.

Contents

1 Order and reason

In an e-mail dated 27/07/2017, IBB GmbH of Groß Schwülper was commissioned by the Fachverband Strohballenbau e.V. to provide an expert opinion on the fire behaviour of load-bearing, separating wall constructions in timber frame construction with a cavity insulation of construction straw in connection with various design variants based on the general building authority inspection test certificate No. P-3048/817/08-MPA BS with regard to classification as fire resistance class F 30 or F 90 according to DIN 4102-2: 1977-09 with one-sided fire exposure for construction projects in the Federal Republic of Germany.

This expert opinion was required as there is not a general usability certification (general building authority test certificate) for all the construction details for the above-mentioned wall constructions in timber panel construction.

2 Fire protection requirements

The above-mentioned load-bearing, separating wall constructions in timber frame construction must, according to the requirements of the building inspection and fire protection concepts, be able to be designed in such a way that the load-bearing, separating wall constructions in a timber frame construction with cavity insulation of construction straw in connection with various design variants in one-sided fire exposure are able to be classified according to the uniform temperature time curve (ETK) pursuant to DIN 4102-2: 1977-09 in fire resistance class F 30 or F 90 pursuant to DIN 4102-2: 1977-09.

This expert opinion is only valid in terms of fire protection safety. Further requirements may arise from the technical building regulations and respective regional building regulations and regulations for special constructions relating to wall constructions, e.g. building physics, structural analysis, electrical engineering, ventilation technology or similar.

This expert opinion does not include the evaluation of the structural design, dimensioning of the wall constructions or the possibly implemented thermal insulation composite systems. It is, however, assumed that there is mathematical proof for use in this regard.

The overall fire protection concept of buildings is not the subject of this expert opinion.

3 Foundations and documents pertaining to this expert opinion

This expert opinion on the load-bearing, room-enclosing wooden beam structures is based on the following:

[1] the general building authority test certificate no. P-3048/817/08-MPA BS dated 08/12/2014 relating to load-bearing, room-enclosing wall construction in fire resistance class F 30 and F 90 pursuant to DIN 4102-2: 1977-09 in the event of one-sided fire exposure, issued to the Fachverband Strohballenbau e.V., Verden,

[2] the general building authority approval no. Z-23.11-1595 DIBt dated 03/01/2014 relating to thermal insulation material made from construction straw bales, issued to the Fachverband Strohballenbau e.V., Verden,

[3] test report no. 3798/999/13 – NB dated 18/02/2014 relating to testing a 360 mm-thick, load-bearing, space-enclosing wooden beam wall construction with straw bale insulation and lime plaster applied to both sides to determine the fire resistance duration in the event of one-sided fire exposure, issued to the Fachverband Strohballenbau e.V., Verden,

[4] the master's thesis on the topic of "The fire protective effect of historic cob plaster on timber ceilings" by Mr H. Opitz, HTWK Leipzig and MFPA Leipzig, September 2017,

[5] DIN 4102-2: 1977-09,

[6] DIN 4102-4: 2016-05,

[7] DIN EN 1363-1: 2012-10,

[8] DIN EN 1365-1: 2013-08,

[9] DIN EN 13501-2: 2016-12,

[10] he handbook on wood fire protection, Kordina, Meyer-Ottens, Deutsche Gesellschaft für Holzforschung e.V. (German Society for Wood Research), Munich, 2nd edition 1994, as well as

[11] the specialist publication "Loam construction rules, terms – building materials – components" (Lehmbau Regeln, Begriffe – Baustoffe – Bauteile), Ed: Dachverband Lehm e.V., Volhard, Franz; Röhlen, Ulrich, 3rd revised edition 2009, Springer Vieweg Verlag.

In addition to these documents, the author's own extensive experience in the field of fire protection is included in this expert opinion on load-bearing, space-enclosing wall constructions in timber frame construction with regard to the fire safety assessment. The engineers of IBB GmbH, Groß Schwülper, have over 30 years of professional experience working in recognised testing institutes.

4 Description of the constructions

4.1 General

The description of the constructions is based on the information provided by the client. Only the most important details relating to fire safety will be described in the following. The assessed wall constructions are load-bearing wooden framed walls with a supporting structure (columns, sleepers, plates) made of solid wood sections, with interposed thermal insulation of compacted construction straw, crossovers made of sheet steel strips fastened to the timber support structure, and two-sided plaster application on a reed mesh plaster base attached to the wooden structure.

The maximum permitted height of the walls is 5.0 m. The maximum stress on the column cross sections is limited to $\sigma = 1.93$ N/mm².

4.2 Wall constructions “F 30” and “F 90”

Notwithstanding the general building authority test certificate (abP) no. P-3048/817/08-MPA BS, see [1], the load-bearing, room-enclosing wall construction in fire resistance class “F 30” and “F 90” should be built to the following specifications:

4.2.1 Substructure (see abP, [1], Section 1.2.1 and 2.2.1.1)

According to the structural requirements, the wooden frame should have a minimum cross section of b x d ≥ 60 mm x 260 mm for wall constructions in class “F 30” and b x d ≥ 60 mm x 360 mm for wall constructions in class “F 90”. The axial dimension for the wooden frames should be a ≤ 1050 mm for both versions.

The attachment of the sleeper and top plate to the frames should be structurally anchored with either two steel screws ≥ 8 x 200 mm, both with three chipboard screws ≥ 6 x 140 mm or with at least two L-shaped sheet steel angles (width and side length approx. 90 mm) with a rib and ring shanked nails Ø x length = 4.0 mm x 40 mm per side. Furthermore, connections should be made using a pin or dovetail according to the structural layout.

Stainless steel spiked bands with a thickness of 2-3 mm (incl. connections to the sleeper and top plate) should be mounted crosswise on the wooden support structure. Alternatively, instead of the above-mentioned spiked bands for stiffening the structure and the wooden composite boards attached to the structure (building class at least B2, bulk density ≥ 600 kg/m²), materials such as, e. g. “OSB” or plywood or solid wood panels (building class at least B2 pursuant to DIN 4102-1 and at least E pursuant to DIN EN 13501-1, bulk density ≥ 330 kg/m³, thickness d ≥ 10 mm) can be used. The dimensioning of the above-mentioned wooden composite boards and plywood or solid

wood panels and the fastening elements should be according to the structural specifications. However, the fasteners (screws or clamps) must be embedded to a minimum depth of ≥ 30 mm into the wooden structure.

Furthermore, wooden planks, d x b ≥ 40 mm x 100 mm, used as struts or for fastening suspended loads (e.g. cabinets) should be built into the walls (embedded depth of the planks or struts in the cavity insulation = 40 mm).

As an alternative to the information of the abPs [1], the retaining ledges (screwed wooden profile b x d = 20 mm x 20 mm or triangular wooden boarders d x d = 38 mm x 58 mm) can be omitted on timber needles for the installation of the fitted straw bales (“construction straw”) in the “F 30” class wall construction.

4.2.2 Insulation (see abP [1], see Sections 2.1 and 2.2.1.1)

The wall cavity should be fitted with ≥ 260 mm thick cavity insulation for class “F 30” and ≥ 360 mm for class “F 90” made from straw bales (“construction straw”) between the studding in accordance with general building authority approval no. Z-23.11-1595.

4.2.3 Plaster application (see abP [1], see Section 2.2.1.3)

Clay plasters (bulk density ≥ 1600 kg/m³) made by various manufacturers (e.g. CONLUTO clay plaster terra coarse damp, CLAYTEC clay base plaster, base plaster) pursuant to DIN 18947 (LPM 0/4 f – S II - 1.8) and according to the loam construction rules of the Dachverband Lehm e.V., see [11], should be applied at an overall thickness of d ≥ 8 mm.

As an alternative to the fibre-reinforced lightweight lime-cement-based plaster mentioned in the abP [1] (lightweight plastering mortar LW, GRÄFIX 73 Pajalith), a comparable 10 mm-thick lime-cement plaster (solid mortar density ≥ 800 kg/m³) made by another manufacturer (e.g. lightweight plastering mortar LW, HESSLER HP 9L) should be used.

As an alternative to the reed mat plaster base described in the abP [1] for applying ≥ 8 mm-thick clay plaster or ≥ 10 mm-thick lightweight lime-cement-based plaster, a 9.5 mm-thick wood fibre panel (building class of at least B2) should be used as a plaster base throughout the entire area and tightly screwed into the wooden frame or wooden substructure pursuant to the specifications of the abP [1], Section 2.2.1.3.

Further description of the constructions will be omitted as these are sufficiently described above and otherwise performed in accordance with the design principles and constraints of the general building authority test certificate no. P-3048/817/08-MPA BS.

When working with the described construction products or construction components, the valid instructions of the manufacturer must be observed.

5 Fire safety assessment of the construction

5.1 Fire safety assessment

From the fire safety perspective of IBB GmbH, Groß Schwülper, the beam cross-sections described in Section 4.2 and the insulating layer of construction straw for the "F 30” class wall construction does not deviate from the general building authority test certificate. Therefore, according to [3] et al., a wooden stud wall consisting of timber studding b x d = 60 mm x 360 mm with cavity insulation made of 360 mm-thick, tightly packed construction straw between the wooden components with spiked bands on one side and a 10 mm-thick lime-cement plaster layer on both sides applied to a reed mat fulfils the performance requirements of DIN EN 1363-1 with regard to the load-bearing capacity, space enclosure and thermal insulation over a test duration of > 90 minutes. Based on the above-mentioned test results, we can derive that, according to the uniform temperature time curve and pursuant to DIN 1363-1, reducing the beam and insulation material thickness to 260 mm over a reduced fire exposure period of 30 minutes will result in compliance with regard to required performance criteria pertaining to preserving the load-bearing effect, thermal insulation and space enclosure. The marginal increase of the distances (5% increase) between the wooden shafts in Section 4.2.1, which are slightly larger by 50 mm, does not significantly or negatively impact the fire protection performance of the walls.

The alternative fortifications of the wooden shafts using steel angles on the sleepers and plates, as well as carpentry wood joints as stated in Section 4.2.1 can be approved, as these only relate to attachments to ensure the positioning of the shafts and therefore have no significant impact on the static load transfer.

The use of spiked bands with an increased steel thickness of 3 mm and alternative use of wooden composite boards, as well as plywood and solid wood panels for bracing the walls can be readily agreed to, as these do not significantly or not adversely affect the basic structures in terms of their fire safety and, in the case of wooden composite boards and plywood or solid wood panels, their additional effect as an insulation or wear layer improve the fire resistance of the wall structures in the event of a fire. Utilising the specified design of the attachment of the wooden composite boards

or plywood / solid wood panels with a minimum embedment depth of 30 mm into the timber support construction sufficiently ensures that the wall coverings, including the plaster base and the plaster, are kept sufficient or do not fall away prematurely in the event of fire exposure.

From a fire protection perspective, the 40 mm-thick wooden struts described in Section 4.2.1 can be used for reinforcement and 40 mm-thick wooden planks may be used for fixing loads, as they only reduce the thickness of the insulating layer of construction straw locally and by 40 mm in the immediate installation area. However, if softwood is used for this purpose, it can compensate for the reduced insulating layer thickness as it has a burn rate of approx. 0.8 mm / min.

The use of retaining ledges can be dispensed with without issue for wall constructions in class “F 30” with regards to the above-mentioned component testing of a two-sided, plastered wooden stud wall insulated with 360 mm-thick construction straw with one-sided fire exposure according to the uniform temperature time curve pursuant to DIN EN 1363 of over 90 minutes with derivable reserve capacities. Due to the arrangement of the retaining ledges directly beneath the plaster application or plaster base, they are exposed directly to the fire after the plaster cladding has failed, so they do not represent a support for the straw compartment in the event of ongoing, progressive fire development. The retaining ledges are therefore of minor importance and can be considered superfluous in a “F 30” construction.

According to the test report [3], the component test proved, among other things, that a 360 mm-thick compartment insulation of construction straw experienced maximum temperature increases on the side away from the fire of 41 K on average and 56 K as a single value after 90 minutes of fire exposure. These fall significantly short of the maximum permitted temperature increases of 140 K on average and 180 K as a single value for the fire protection performance criteria of insulation. Reduction of the insulation layer to 260 mm for a “F 30” wall construction pursuant to Section 4.2.2 can therefore be accepted without hesitation due to the existing reserve capacities.

Provided that the clay and lime-cement plasters of other manufacturers is fundamentally the same with regard to their composition and material properties, as well as the plaster application thickness as described in Section 4.2.3, we can assume from a fire protection perspective that there would be a comparable adhesion and protective effect in the event of a fire based on the existing test results on various plaster coatings.

There are no concerns with regard to the use of wood fibre panels instead of reed matting as a plaster base [4]. For example, component tests have proven that there is a comparable adhesive bond between clay plaster on wood fibre panels and reed mats in the event of fire exposure.

On the basis of the general building authority test certificate [1], the fire protection evidence given in Section 3 and the further test results on wooden stud walls, the load-bearing, space-enclosing wall constructions in timber frame construction with cavity insulation of construction straw, in conjunction with various design variants over a fire exposure period of 30 minutes or 90 minutes of one-sided fire exposure according to the uniform temperature time curve pursuant to DIN 4102-2: 1977-09 fulfil the required protection goals with regard to

- spatial enclosure,
- the permitted temperature increase above the initial temperature and
- the load-bearing capacity,

insofar as the construction details in Section 4 are adhered to and that the design is otherwise constructed according to the boundary conditions and construction principles of general building authority test certificate no. P-3048/817/08-MPA BS.

5.2 Summary and conclusions

From a fire protection perspective, IBB GmbH, Groß Schwülper recommends that the above-mentioned wall construction with designs pursuant to the information provided in Section 4.1 (wall construction “F 30”) and 4.2 (wall construction “F 90”) in the event of a one-sided fire exposure of 30 minutes or 90 minutes of one-sided fire exposure according to the uniform temperature time curve (ETK) pursuant to DIN 4102-2: 1977-09 are classified as load-bearing, space-enclosing walls in

Fire resistance class “F 30” (“F 30-B” for short)
pursuant to DIN 4102-2: 1977-09

and

Fire resistance class “F 90” (“F 90-B” for short)
pursuant to DIN 4102-2: 1977-09

as the deviations in the insulation, substructure and plaster described in Section 4 have been assessed as being non-essential.

This expert opinion relates exclusively to the fire protection assessment of the above-mentioned construction on the basis of the information provided by the client and the presented foundational information, and makes no statements relating to the structural analysis of the components.

6 Special instructions

- This expert opinion can be used in conjunction with the above-mentioned general building authority test certificate no. P-3048/817/08-MPA BS in construction processes as a basis for proof of conformity, as the deviations described in Section 4 are assessed as being “non-essential” from a fire protection perspective. The issuance of proof of conformity for the construction (with indication that the created construction has “non-essential” deviation from the construction principles and boundary conditions pursuant to the above-mentioned fire protection proof) is the responsibility of the building manufacturer (builder).
- Changes to and additions of construction details (derived from this expert opinion) are only possible after consultation with IBB GmbH, Groß Schwülper.
- This expert opinion is only valid if the subsequent load-bearing (reinforcing or load-discharging) components have at least the same fire resistance class as the assessed walls.
- Proper execution is the sole responsibility of the executing company.
- When using the construction materials or products mentioned in Section 4, the valid processing guidelines of the manufacturers must be observed.
- This expert opinion only applies to construction projects in the Federal Republic of Germany.
- The validity of this expert opinion expires on 24/04/2023.
- The period of validity may be extended on request and depending on the latest technology.