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Overview of sustainable building materials and their possible applications – Part 1 - Biobased materials

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Inhalt

1 Introduction

Within the REBUMAT project, AP3 will provide an overview of sustainable materials, bio-based renewable materials and recycled materials. This report is intended to help with the selection of bio-based building materials for use in Vietnam.

2 Bio-based materials used in Europe

Bio-based insulation and building materials are gaining attention in Germany and Europe due to their environmental benefits and sustainability. However, their market share remains relatively modest compared to conventional materials. According to a survey by the Fachagentur Nachwachsende Rohstoffe e.V. (FNR [1]), bio-based insulation materials, known as NawaRo (nachwachsende Rohstoffe) insulation, accounted for approximately 9 % of the total insulation market. This represents a 2 % increase since 2011. In comparison, fossil-based insulation materials held a 48 % market share, while mineral-based insulations had 43 %. A report by Ceresana indicates that in 2021, around 235 million cubic meters of insulation materials were utilized in Europe, primarily comprising mineral wool (glass and stone wool), polystyrene insulation (EPS and XPS), and polyurethane (PUR/PIR). Bio-based insulation materials constituted only a small fraction of this total. Within the bio-based insulation segment, certain materials are more prevalent; Wood Fiber Insulation: Approximately 58 % market share, cellulose Insulation: Around 32 % market share, other Materials (e.g., hemp, flax, sheep wool): About 10 % market share. These materials are utilized in various forms, including board insulation (52 %), blown-in insulation (24 %), and mat insulation (24 %). Despite their current modest market share, the demand for bio-based insulation materials is expected to rise [2]. Ceresana's market report anticipates that the revenue for these "green" building materials in Europe will grow to over € 2.3 billion by 2032. (CERESANA MARKET RESEARCH [3]). While bio-based insulation and building materials currently represent a small portion of the market in Germany and Europe, their share is gradually increasing. Factors such as environmental concerns, sustainability goals, and advancements in material performance are contributing to their growing adoption.

3 Bio-based materials used in Asia und Vietnam

Bio-based building and insulation materials utilized in Vietnam and other Asian countries, are listed with their physical properties and sources in 4. These are materials like rice husk, hempcrete, bamboo and coconut fiber. These bio-based materials offer sustainable alternatives to conventional building materials, contributing to energy efficiency and environmental friendliness in construction practices. In Vietnam, bio-based building materials have a long tradition. Historically, materials such as bamboo, rice straw, and wood were widely used in construction due to their availability and adaptability to the tropical climate. These natural resources provided cost-effective and sustainable solutions for housing. With the increasing urbanization and industrialization of the 20th

century, the trend shifted toward conventional building materials like concrete and steel, which were seen as symbols of modernity and durability. These materials came to dominate the construction sector, particularly in urban areas. In recent years, however, Vietnam has experienced a revival of bio-based building materials, driven by a growing awareness of environmental issues and the need for sustainable building practices. Projects comparable to ReBuMat focus on construction using bio-based materials, recycled resources, and circular building approaches. Bio-based building materials currently account for only a small percentage of the total consumption of construction materials in Vietnam. The exact proportions vary depending on the region and specific projects, but conventional materials such as concrete and steel continue to dominate the market. However, there is a growing trend toward integrating bio-based materials, particularly in projects that emphasize sustainability and environmental friendliness. The Vietnamese government has recognized the importance of sustainable building materials and has adopted strategies to promote their development through 2050. These strategies aim to meet modern international standards, enhance energy efficiency, and increase competitiveness in the global market [4].

4 Overview and description of biobased materials

The following is a list of insulation and building materials currently used in Europe and Asia, and especially in Vietnam. The list contains information on production and composition, forms of delivery, technical characteristics and some typical advantages and disadvantages.

4.1 Hemp

Raw materials production and composition

Hemp insulation materials are made from the fibers of the hemp plant. This is usually a fast-growing annual plant which can be grown without much effort. Depending on the legal situation, care must be taken that only varieties with low THC content may be planted. After harvesting the adult plants, the fibers of the plant are separated from the partially woody plant stems. From the harder parts the so-called shives can be produced bulk materials or in connection with lime even hemp stones. The fibrous parts can be used to make insulating mats and stuffing materials.

Delivery form and application

Hemp insulation can be used both as loose tamping material and as insulation mats. The insulation is particularly suitable for compartment insulation in wooden structures, both on exterior and interior walls. It should be noted that the insulation must be protected from the effects of weather and moisture.

Additional comments

Hemp is a fast-growing and a renewable resource that requires less water and pesticides.

Hemp allows moisture regulation and reducing the risk of mold. Hemp is resistant to pests and does not degrade easily over time. Hemp may not be as widely available as other insulation options. While not highly flammable, hemp still requires fire treatment to enhance its fire resistance.

Figure 1: Hemp mats, photo from [5].

Building physics parameters

Thermal conductivity W/mK]	0,04
Bulk density [kg/³]	30 – 110
Water vapor diffusion resistance	1 – 2
Thermal capacity [J/kgK]	1600 - 2300
Fire behavior EN 13501-1	E

Manufacturer

Manufacturer	Product name
BAFA Neu GmbH https://www.bafa-gmbh.de/	Hanfschäben-Kalk-Dämmung
Bioformtex GmbH www.bioformtex.de	Hanfdämmmatte HDM

References: [5][6]

4.2 Hempcrete, Hemp blocks

Raw materials production and composition

Hempcrete or hemplime is biocomposite material, a mixture of hemp hurds (shives) and lime, sand, or pozzolans, which is used as a material for construction and insulation. It is marketed under names like Hempcrete, Canobiote, Canosmose, Isochanvre, and IsoHemp. Hempcrete is easier to work with than traditional lime mixes and acts as an insulator and moisture regulator. It lacks the brittleness of concrete and consequently does not need expansion joints. "IsoHemp" hemp block is a self-supporting masonry element with no structural role. It is made from hemp shives and a mixture of air and hydraulic lime. The product is moulded, pressed, hardened and air-dried without the need for heat input.

Delivery form and application

Hempcrete has been used in France since the early 1990s, and more recently in Canada, to construct non-weight bearing insulating infill walls, as hempcrete does not have the requisite strength for constructing foundation and is instead supported by the frame. Hempcrete was also used to renovate old buildings made of stone or lime. France continues to be an avid user of hempcrete, and it grows in popularity there annually. Canada has followed France's direction in the organic building technologies sector, and hempcrete has become a growing innovation in Ontario and Quebec.[11]

There are two primary construction techniques used right now for implementing hempcrete. The first technique consists of using forms to cast or spray hempcrete directly in place on the construction site.[7] The second technique consists of stacking prefabricated blocks that are delivered to the project site similar to masonry construction.[7] Once hempcrete technology is implemented between timber framing, drywall or plaster is added for aesthetics and increased durability.[7] Hempcrete can be used for a number of purposes in buildings, including roof, wall, slab, and render insulation, each of which has its own formulation and dosages of the various constituents respectively

Additional comments

Typically, hempcrete has good thermal and acoustic insulation capabilities, but low mechanical performance, specifically compressive strength. Hemp blocks are a lightweight, insulating material, finishing plaster, or a non-load bearing wall, ideal for most climates, since it combines insulation and thermal mass while providing a positive impact on the environment. Hempcrete has a high silica content, which makes it more resistant to biological degradation than other plant products.

Figure 2: Wall with hemp blocks, photo from [7].

Building physics parameters

Thermal conductivity [W/mK]	0.06–0.6
Bulk density [kg/³]	200 – 960
Water vapor diffusion resistance	5 – 25
Thermal capacity [J/kgK]	1000 - 1700
Fire behavior EN 13501-1	A1

Manufacturer

Manufacturer	Product name
BAFA Neu GmbH https://www.bafa-gmbh.de/	Hanfschäben-Kalk-Dämmung
Bioformtex GmbH www.bioformtex.de	Hanfdämmmatte HDM

References: [5][6][7]

4.3 Flax

Raw materials production and composition

The fibers of the flax plant, which is also called linum, are used as the raw material for flax insulation materials. The fibers for the insulating material are obtained from the stalks of the plant and mechanically felted in industrial processes. The resulting felt webs are processed into insulation mats by means of binders or reinforcing fibers.

Delivery form and application

Flax insulation can be used as flexible mats in wooden structures as compartment insulation on both exterior and interior walls. The insulation must be protected from weathering and moisture. In loose form, flax can be used as stuffing material bulk or blow-in insulation even without additives. The boards are cut to size using an oscillating foxtail or a simple circular saw.

Additional comments

Flax has at the moment a limited availability and the fire resistance has to be improved. It has a potential for moisture absorption. It is a lightweight and strong material.

Figure 3: Photo of Elke Wetzig (elya) - Eigenes Werk, CC BY-SA 3.0,

Building physics parameters

Thermal conductivity [W/mK]	0,039
Bulk density [kg/³]	30 – 40
Water vapor diffusion resistance	1 – 2
Thermal capacity [J/kgK]	1550 - 2300
Fire behavior EN 13501-1	E

Manufacturer

Manufacturer	Product name
Naturfaser Fölser www.naturfaser-foelser.at	Flachsfloc
Vicarius s.r.o www.naturflax.cz/de	Naturflax

References: [5][6]

4.4 Wood-Wool

Raw materials production and composition

Wood wool is primarily used for the production of wood wool lightweight panels. Wood wool consists of long-fibered spruce or pine chips which are produced from well-dried residual wood from the wood processing industry. The wood fibers are mixed with mineral binders such as cement or magnesite and pressed into boards.

Delivery form and application

Wood wool lightweight boards are available on the market in handy format and are produced with thicknesses from 1.5 cm to 15 cm. The boards have low thermal insulation properties and are therefore mostly used in combination with other insulation materials. A three-layer structure is also common, in which a core of EPS, or mineral wool is connected with cover layers of wood wool. Since the wood wool board is suitable as a plaster base board, it is used on exterior and interior walls as well as in ceilings and roof areas. In the exterior, the boards should be protected from splashing water and moisture.

Additional comments

Wood wool can absorb moisture, which may lead to mold growth and reduced effectiveness if not properly treated. It may not have sufficient fire resistance unless treated with fire-retardant chemicals. Building materials made of wood wool are also readily available due to the ready availability of the raw material.

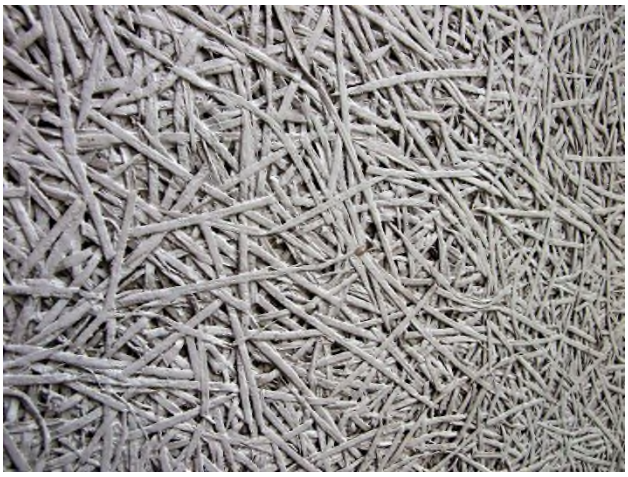

Figure 4: Board with wood wool fibers [8].

Building physics parameters (Holzwolleplatte)

Thermal conductivity [W/mK]	0,09
Bulk density [kg/³]	330 – 500
Water vapor diffusion resistance	2 – 5
Thermal capacity [J/kgK]	2100
Fire behavior EN 13501-1	B

Manufacturer

Manufacturer	Product name
Fibrolith Dämmstoffe GmbH www.fibrolith.de	Fibrolith Leichtbaublatte
Knauf Insulation GmbH www.heraklith.de	Heraklith BM

References: [5][6]

4.5 Chipped wood

Raw materials production and composition

For this insulation, the wood shavings from wood species such as fir, spruce, or pine that are produced in wood processing are used. The chips are sieved and dedusted for use as insulation. Depending on the manufacturer, the chips are also mixed with mineral additives such as clay or cement, or impregnated with whey and soda lye to protect against fungal attack.

Delivery form and application

Wood chip insulation is used as loose fill, for example, to insulate layers of beams, or as blow-in insulation in wooden structures.

Additional comments

Wooden chip insulation is not suitable as core insulation of double-shell masonry.

Figure 5: Photo of chipped wood, Fraunhofer-IBP.

Building physics parameters

Thermal conductivity [W/mK]	0,045
Bulk density [kg/³]	90 – 360
Water vapor diffusion resistance	2
Thermal capacity [J/kgK]	k.A.
Fire behavior EN 13501-1	E

Manufacturer

Manufacturer	Product name
CEMWOOD GmbH www.cemwood.de	CW020
Holz-Lehmhaus GmbH www.holz-lehmhaus.eu	Jasmin

References: [5][6]

4.6 Wood fiber

Raw materials production and composition

As raw material for the wood fiber insulating materials, weak and residual wood from the wood processing industry is defibered. Depending on the product, the fibers are mixed in a wet process to form a wood fiber pulp and pressed into a board, or bound with binders such as PUR resin. Polyolefin fibers are also used to produce flexible insulation mats. Wood fiber insulating materials are often used with further additives such as wood glue for bonding different layers, kerosenes or latex for water repellency and aluminum sulfate, borates for fire protection and resistance.

Delivery form and application

Wood fiber insulating materials are available on the market both as a solid board material for planking wooden structures, above-rafter insulation or also as ETICS, but can also be used in flexible form as an insulating mat as cavity insulation in roofs, walls and ceilings. As loose fill, the insulation material can also be applied manually or as blow-in insulation in cavities.

Additional comments

Good availability. While wood itself is flammable, treated wood fiber insulation can meet fire safety standard. Wood fiber can absorb and release moisture, helping to prevent condensation and mold growth. But it is sensitive to water and can degrade. Sometimes it is difficult to install because of sealing problems.

Figure 6: Thingermejig - STEICO flex Natural Wood Fibre Insulation, CC BY-SA 2.0.

Building physics parameters

Thermal conductivity [W/mK]	0,036 -0,040
Bulk density [kg/³]	30 – 270
Water vapor diffusion resistance	1 – 5
Thermal capacity [J/kgK]	2100
Fire behavior EN 13501-1	E

Manufacturer

Manufacturer	Product name
AGEPAN SYSTEM c/o www.sonaearauco.com	AGEPAN
INTHERMO GmbH www.inthermo.de	Inthermo
STEICO https://www.steico.com/	STEICOflex

References: [5][6]

4.7 Cork

Raw materials production and composition

The raw material for cork insulation comes from the bark of the cork oak tree native to North Africa and Southwest Europe. The bark of the cork oak can be peeled off every 9 to 10 years. The harvested cork bark is crushed and baked with the addition of hot steam and pressure, which causes the cork granules to bond and expand. This processing method binds the cork naturally and no other additives are necessary.

Delivery form and application

The cork granulate produced after crushing can also be used as insulation bulk material without further processing. Cork insulation boards can be used for most insulation work not in contact with the ground as long as they are protected from moisture and direct irrigation. Cork insulation boards are also suitable for use as plaster base boards in ETICS.

Additional comments

Naturally resistant to moisture, preventing mold and rot. Resistant to compression, meaning it maintains its shape and insulating properties over time. Its cellular structure makes it highly effective for noise reduction and acoustic control. Harvesting is limited to specific regions (mainly the Mediterranean), affecting price and supply.

Figure 7: Cork insulation board [9].

Building physics parameters

Thermal conductivity [W/mK]	0,04
Bulk density [kg/³]	120
Water vapor diffusion resistance	2 – 8
Thermal capacity [J/kgK]	1800
Fire behavior EN 13501-1	E

Manufacturer

Manufacturer	Product name
Haacke Cellco GmbH www.haacke-cellco.de	Cellco Kork-Dämm-Platte

References: [5][6] [9]

4.8 Cotton wool

Raw materials production and composition

The raw material for cotton insulation comes from the seed hairs of the cotton bush. For use as insulation, additives must be added to the raw material for protection against insect infestation and fire protection. In addition to production from the plant raw material, an insulating material made from recycled cotton from textiles is also conceivable.

Delivery form and application

Cotton insulation can be used as insulation mat for compartment insulation, but can also be used as flakes in the blow-in process. Furthermore, insulation pigtails are available as stuffing material. Since cotton has a high water absorption capacity, but dries back relatively slowly, it should be protected from moisture and only used in constructions that are harmless to moisture.

Additional comments

At the moment it's not commonly used as a primary structural material in construction. Cotton wool requires treatment for fire resistance. It has a limited structural strength but it is easy to work with.

Figure 8: Photo of a cotton wool mat [5].

Building physics parameters

Thermal conductivity [W/mK]	0,04
Bulk density [kg/³]	20 – 60
Water vapor diffusion resistance	1 – 2
Thermal capacity [J/kgK]	840 - 1300
Fire behavior EN 13501-1	k.A.

Manufacturer

Not available

References: [5]

4.9 Sheep wool

Raw materials production and composition

Depending on the manufacturer, 100% virgin wool without additives is used for sheep wool insulation, which is only cleaned, washed and degreased before use. In some products, artificial or natural fibers and moth repellents are added.

Delivery form and application

Sheep wool is commonly used in insulation for walls, roofs, and floors. It is also used in acoustic insulation and as a sustainable option in eco-friendly building projects. First and foremost, flexible insulation fleece mats are made from sheep's wool, which is used as compartment insulation in wooden structures. Also the material is available as stuffing material as sheep wool plait.

Additional comments

Can be less available in some regions. It may compress over time. It requires treatment for pest resistance.

Figure 9: Photo of a sheep wool insulation mat [5].

Building physics parameters

Thermal conductivity [W/mK]	0,04
Bulk density [kg/³]	25 – 30
Water vapor diffusion resistance	1 – 5
Thermal capacity [J/kgK]	960 – 1300
Fire behavior EN 13501-1	E

Manufacturer

Manufacturer	Product name
Alchimea Naturwaren GmbH www.alchimea.de	Alchimea lana

References: [5][6]

4.10 Reed

Raw materials production and composition

Reed is a marsh plant that grows up to 5 m high worldwide and is very fast-growing under the right conditions. The reed as a raw material for an insulation material is harvested by machine after the plant has died and dried out. For insulation boards, the reed stalks are held together across the direction of growth with galvanized metal wires. The boards are produced in a continuous process and can thus be shortened to desired dimensions

Delivery form and application

For many years, reed has been used as a heat-insulating roof covering, in which simple bundles of reed are fastened on top of each other on the roof. As a pure insulating material, reed mats are mainly used as plaster base plates on the outer facade of solid buildings or wooden constructions. The reed mats can also be used as plaster base mats for interior insulation. In the transverse direction, the panels can be cut with a simple circular saw; in the longitudinal direction, the wires must be cut and re-fixed.

Additional comments

Reed is naturally resistant to pests. It is biodegradable.

Figure 10: Photo of a reed board, (Fraunhofer IBP).

Building physics parameters

Thermal conductivity [W/mK]	0,065
Bulk density [kg/³]	150
Water vapor diffusion resistance	3 – 6,5
Thermal capacity [J/kgK]	1200
Fire behavior EN 13501-1	E

Manufacturer

Manufacturer	Product name
Claytec e.K http://www.claytec.de/	Schilfrohr-Leichtbauplatten
Hiss Reet www.hiss-reet.de	Schilfprodukte

Alchimea Naturwaren GmbH www.alchimea.de	Alchimea lana

References: [5][6] [10]

4.11 Typha

Raw materials production and composition

Typha Angustifolia, better known as bulrush, is a paludiculture that is mainly found on the banks of stagnant or slow-flowing waters. The plants are harvested in the winter months when the leaf bundles have dried and the nutrients they contain have been redistributed to the rhizomes. The raw material can be processed into insulating materials without any further additives. Different binders with their respective advantages and disadvantages can be used for the production of board materials. With magnesite as a mineral binder, a unique combination of insulating effect and strength with excellent fire protection is achieved.

Delivery form and application

Typha can be used in small-cut form as blown-in or loose-fill insulation material in compartments and beam layers. Of particular interest is its use as an insulating and load-bearing building material, in which the Typha leaf particle rods with their sponge and supporting fabric are combined with magnesite to form a building material panel.

Additional comments

Like reed, it is biodegradable, but as a blown-in or loose-fill insulation material, unlike magnesite-bonded board, it must be treated for fire resistance. The main problem at present is the limited availability of raw materials in some regions.

Figure 11: Thyhaboard with a magnesite binder, photo Fraunhofer IBP.

Building physics parameters of the Typhaboard

Thermal conductivity [W/mK]	0,055
Bulk density [kg/³]	285
Water vapor diffusion resistance	20 – 28
Thermal capacity [J/kgK]	1500
Fire behavior EN 13501-1	B
Compressive strength [kPa]	500

Manufacturer

Not available

References:
Krus, M.; Theuerkorn, W.; Großkinsky, Th.; Bichlmair St.: Advantages and use of a newly developed load-bearing insulation material made of cattail. Chapter 1.5, P. 75-106.
In: Energy-Efficient Retrofit of Buildings by Interior Insulation - Materials, Methods, and Tools; 1st Edition - November 24, 2021. Editors: Thomas Stahl, Karim Wakili. Paperback ISBN: 9780128165133; eBook ISBN: 9780128165157.
Krus, M., Theuerkorn, W., Großkinsky, T., Kraft, R. (2023). Development of Various Building Materials Based on Paludiculture Cattail. In: Amziane, S., Merta, I., Page, J. (eds) Bio-Based Building Materials. ICBBM 2023. RILEM Bookseries, vol 45. Springer, Cham. https://doi.org/10.1007/978-3-031-33465-8_29

4.12 Seagrass (Zostera Marina)

Raw materials production and composition

For seagrass as an insulating material, a distinction is made between Posidonia oceanica, which is found exclusively in the Mediterranean, and Zostera marina, a long-fibrous seagrass that occurs on many coasts of the Atlantic and Pacific. The dead leaves of the Zostera marina are washed up on the coasts and can be collected there by machines. The rohmaterila is simply cleaned and dried and can then be used as insulation without further treatment.

Delivery form and application

Without further processing of the raw material, the seaweed can be used directly as a tamping material as compartment insulation on interior and exterior walls and in the roof and ceiling area. The insulation must be protected from moisture and weathering. A board material in pressed form with mineral adhesives is also conceivable, but is not currently available on the market.

Additional comments

Limited availability in some regions, it may attract pests. It is biodegradable.

Figure 12: Seagrass from the Eastern see, photo by Fraunhofer IBP.

Building physics parameters

Thermal conductivity [W/mK]	0,043
Bulk density [kg/³]	75
Water vapor diffusion resistance	17
Thermal capacity [J/kgK]	1500
Fire behavior EN 13501-1	B

Manufacturer

Manufacturer	Product name
Seegrashandel GmbH www.seegrashandel.de	Seegras

References: [6] [10]

4.13 Straw

Raw materials production and composition

Straw, a residual product from the agricultural cultivation of grain and rice, has always been used as a building and insulating material. Depending on the form of delivery, the straw produced during harvesting is pressed into bales as whole stalks or chopped into smaller pieces. As loose material or in straw bale form, no further additives are necessary. For sheet materials, additional adhesives are necessary.

Delivery form and application

Pressed straw bales can be used in timber construction as infill of the stud frame, if the distances are planned according to the dimensions. A load-bearing structure made of straw bales is also possible in practice. For this purpose, wooden frames are inserted between the forked straw bales for fastening Platen materials. Straw as loose and shredded material can be used both as fill and as blow-in insulation. All construction methods using straw must be protected from pest infestation and moisture. Therefore, it is not possible to use it near the ground

Additional comments

Straw is a renewable resource and thus environmentally friendly. In many regions, straw is inexpensive and readily available.

Straw has good insulation properties and allows moisture to pass through, improving indoor air quality. But straw is flammable and requires special fire protection measures.

Straw can be infested by pests, requiring additional maintenance, in humid regions the high humidity can lead to mold growth. The use of straw requires specific building knowledge and techniques.

Figure 13: Photo of a wall with straw insulation [6].

Building physics parameters

Thermal conductivity [W/mK]	0,045
Bulk density [kg/³]	75
Water vapor diffusion resistance	1,5
Thermal capacity [J/kgK]	2000
Fire behavior EN 13501-1	E

Manufacturer

Manufacturer	Product name
BauStroh GmbH www.baustroh.de	Baustroh
DPM Holzdesign GmbH www.isostroh.com	Iso-Stroh IDEAL

References: [5][6]

4.14 Cellulose

Raw materials production and composition

Cellulose is basically the main component of plant cell walls and is used as a raw material for paper production. For the production of cellulose insulation, only waste paper is used, which is defibered in a dry process with the addition of boric salts and other additives.

Delivery form and application

The cellulose flakes are mainly used as blow-in insulation in wooden structures, but can also be inserted loosely in joists as loose-fill insulation. As an interior insulation system in renovation, a plasterable system is also possible, in which a cellulose fiber mixture is sprayed on.

Additional comments

Requires careful handling during installation and installation by professionals. Settling over time can cause problems.

Figure 14: Photo by www.thermofloc.com/de.

Building physics parameters

Thermal conductivity [W/mK]	0,043
Bulk density [kg/³]	105
Water vapor diffusion resistance	3 – 5
Thermal capacity [J/kgK]	2100
Fire behavior EN 13501-1	E - B

Manufacturer

Manufacturer	Product name
Isocell GmbH www.isocell.com	Isocell
CWA Cellulose Werk Angelbachtal GMBH www.climacell.de	Climacell S

References: [5][6]

4.15 Coconut fiber, coir

Raw materials production and composition

Coconut fiber comes from the husk residues of the coconut and is a residual material from the coconut harvest. For the insulation material, the fibers are processed and mixed with fire-retardant additives and with bitumen or latex to form a water repellent and then processed into nonwovens.

Delivery form and application

Coconut fiber mats are available in insulation thicknesses up to 120 mm and can be used as a layered insulation on interior and exterior walls. The insulation material should be protected from weathering and moisture and is not suitable for use in structures in contact with the ground.

Additional comments

Coconut fiber is commonly used in insulation materials, as a reinforcing agent in composites, and in erosion control products. Its natural properties make it a popular choice in eco-friendly building projects. It is a lightweight product and easy to handle. Good sound insulation.

Figure 15: Innotec Systems, Kempten www.baunetzwissen.de.

Building physics parameters

Thermal conductivity [W/mK]	0,042
Bulk density [kg/³]	70 - 145
Water vapor diffusion resistance	1 – 2
Thermal capacity [J/kgK]	2000
Fire behavior EN 13501-1	k.A.

Manufacturer

Manufacturer	Product name
Gittel Triagwerke GmbH www.gittel-naturdämmstoffe.de	Kokosdämmstoff

References: [5][6]

4.16 Meadow grass

Raw materials production and composition

For the insulation material made of meadow grass, the commonly occurring monocotyledonous plants are used from which cellulose fibers are produced by a thermal-mechanical wet digestion process. From these cellulose fibers, an insulating material suitable for blowing in is produced by adding fire retardants.

Delivery form and application

The meadow grass insulation material can be installed as blow-in insulation on site as cavity insulation, or as loose fill installed manually in hollow spaces such as between ceiling joists.

Additional comments

Limited availability and sourcing issues. Limited structural strength if used alone.

Figure 16: Photo of meadow grass [10].

Building physics parameters

Thermal conductivity [W/mK]	0,039
Bulk density [kg/³]	65 – 75
Water vapor diffusion resistance	1 – 2
Thermal capacity [J/kgK]	2500
Fire behavior EN 13501-1	k.A.

Manufacturer

Manufacturer	Product name
Biowert AG www.biowert.com	AgriCell BW

References: [10]

4.17 Bamboo

Raw materials production and composition

Bamboo is a fast-growing grass that reaches maturity in 3–5 years, making it a renewable and sustainable resource. It is primarily cultivated in tropical and subtropical regions such as Asia, South America, and Africa. Once harvested, the stalks are processed into various forms (e.g., poles, strips, laminated boards). Cellulose (40-50%): Provides strength and flexibility.
Lignin (20-30%): Adds rigidity and stiffness.
Hemicellulose (15-25%): Enhances bonding and structure.
It also contains silica and natural waxes, contributing to its durability and resistance to pests

Delivery form and application

Natural bamboo poles (unprocessed).
Splits and strips.
Engineered bamboo products like laminated boards, flooring panels, and composite materials.
Bamboo mat boards and veneers. Structural Use: Scaffolding, bridges, and framing for buildings.
Non-structural Use: Flooring, roofing, wall paneling, furniture, and decorative elements.
Composites: Bamboo fibers are used in cement reinforcement or as part of engineered wood products.

Additional comments

Rapid growth rate, abundant availability, and carbon sequestration make it highly eco-friendly. Bamboo has a high Strength-to-Weight Ratio and is stronger than steel (per unit weight) in tensile strength and highly lightweight. It has an excellent resistance to seismic forces. It is affordable, especially in regions where it is locally available.
Bamboo is susceptible to pests and rot. Without proper treatment, bamboo is prone to termite attacks and decay. Is is vulnerable to swelling and shrinking in high humidity.
Compared to materials like concrete or steel, untreated bamboo has a shorter lifespan. It requires treatment to improve fire resistance. Processing can be difficult due to natural variation in size and shape.

Figure 17: Photos of raw bamboo and laminated bamboo, Dr. Huang at Fraunhofer-IBP.

Building physics parameters

Thermal conductivity [W/mK]	0,1 – 0,3
Bulk density [kg/³]	600 - 800
Water vapor diffusion resistance	5 – 10
Water vapor diffusion resistance (boards)	10 - 40
Thermal capacity [J/kgK]	2100 - 2400
Fire behavior EN 13501-1	-

Manufacturer of bamboo in Vietnam

Manufacturer	Product name
BWG Bamboo Vietnam, BambuBuild – Bambu Co.,Ltd, EcoBambu, Bamboo Hardwoods Vietnam Co., Ltd, Bamboo Vietnam Export (BAMBOOEX™)	-

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