

# HEMP IN CONSTRUCTION

--A new sustainable natural building material

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## **ABSTRACT**

*This paper gives an overview of hemp and hemp product, explain the advantage of hemp as building material to achieve the sustainability rather than traditional building material. It also gives a preliminary introduction of construction methods of hemp-based building, in order to show the advantages of hemp, not only in terms of the technical properties of the building material, but also in terms of the environment and energy consumption.*

**KEYWORDS:** *natural building material, hemp, thermal insulation, sustainable, etc.*

## **I. INTRODUCTION**

Traditional building material, such as wood, concrete, are usually mined from the earth or harvested from rapidly depleting forests. With construction consuming a whopping 40% of the world's global energy and resources, it is imperative that architectural industry moves towards more sustainable practices in the face of threats of climate change. Therefore, natural building material come to be a better choice for its substantiality and reproducibility. In Holland, hemp is a popular natural material with extensive production. And many of characters of hemp support it as a universal natural building material in the coming days.

## **II. HISTORICAL DEVELOPMENT AND BACKGROUND OF HEMP**

Hemp, which also called cannabis, has a long history as plant and a variety of uses in a number of industries. We can learn about the possibilities of hemp use in the field of architecture from history. In the past, hemp was most often used for the production of ropes, netting, textiles, later in China for paper production. Hemp oil has been used in cosmetics and also in colour or light production. In construction, hemp was used in combination with raw materials that could be harvested or produced directly at the site. Archaeologist have confirmed the use of hemp in the construction could be dated back at least 1,500 years. It can be found in wooden-framed buildings of central

Europe. And hemp mortar has been discovered in ancient Merovingian bridge abutments in France<sup>1</sup>.



Fig.1: Merovingian Hemp bridge (500-750 A.D)

Modern building with hemp originated in France in the 1980s when people were experimenting to find an appropriate replacement for deteriorated wattle and daub in medieval timber-frame buildings.<sup>2</sup> The use of hemp as building material has gradually spread, from Europe to more around the world, and the application of this natural building material are continues increasing, not only in the repair of older buildings, but also in new constructions. In Netherlands, it has developed hemp industry and market, and the relevant skill and technique are also been used in many projects.

### **Why we use hemp as building material?**

Compare to other traditional building material such as concrete, wood, hemp shows a better performance on many aspects:

#### 1. Zero carbon emissions

Hemp absorb large amounts of carbon dioxide from the atmosphere as they grow. Overall, the production and use of hemp product are very low-impact processes, and even considering the transportation and energy consumption, the amount of carbon they absorb in their lives exceeds all of these and is greater than most traditional building materials.

#### 2. Moisture regulating

Hempcrete is super breathable and able to regulate humidity. This is because when the humidity go high, hemp will absorb moisture from the air into the wall. Then, when the humidity drops, they are released into the air. It could prevent the growth of mold and avoids keeping the humidity at an appropriate level that prevents bacterial growth. And to achieve this effect does not require a ventilation system.

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<sup>1</sup> Nigel Isaacs, 2014, Hempcrete – An Environmentally Friendly Material

<sup>2</sup> Nigel Isaacs, 2014, Hempcrete – An Environmentally Friendly Material

### 3. Thermal insulation

Hemp building material has very good thermal properties. Regardless of the weather, buildings built with hemp remain unchanged in temperature. This is due to the combination of its insulation effect and thermal mass. Therefore, hemp concrete houses are very comfortable, warm in winter and cool in summer.

### 4. Waste recycling

The yield of hemp is very high, and usually hemp production does not use the interior of the plant, it is considered a by-product. Using this wasted material, hemp products for building material has become an environmentally friendly solution for waste recycling.

### 5. Fire protection

Hemp concrete blocks will scorch slightly when burning, but they have better fireproof than traditional houses. Depending on the size and thickness of the hemp brick, they will not catch fire within two hours.

Moreover, industrial use hemp is very easy to maintain, it does not require pesticides, fungicides or fertilizers. Most of the factories used to manufacture Hempcrete are surplus materials from other industries that use hemp.

Compare to traditional building material, hemp building material has better design flexibility, which means structural design is not limited by shape, as curves can be made. And its low density will reduce weight of the building permits shallower foundations.

## III. HEMP PRODUCT IN CONSTRUCTION

Hemp has a history in construction. Roman engineers used its fibers to enhance the mortar for bridge abutments. Nowadays, hempcrete, a building composite similar to concrete, is the most popular hemp product in construction. Moreover, hempcrete can be used in combination with other building materials to form both floors and roofs, providing an insulating layer.

### **Hempcrete**

Hempcrete was first developed in France as a method of adding thermal performance to medieval timber frame buildings, whilst allowing the historic building fabric to continue working in the way it was intended to<sup>3</sup>.

The hemp plant "woody" contains a large amount of silica, which is unique to hemp compared to other natural fibers. This silica allows everything to be tightly combined to create the so-called Hempcrete. Hempcrete is bio-composite mixture of hemp shive, lime binder and water. A lightweight material, it is about one eighth the weight

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<sup>3</sup> UK hempcrete, traditional and historic buildings, <https://www.ukhempcrete.com/services/traditional-and-historic-buildings/>

of concrete. Hempcrete can be used to construct walls, floors and roofs; or molded (monolithic), sprayed or precast (e.g. hemp bricks or panels)<sup>4</sup>. For example, hempcrete could be made in block form — similar to concrete masonry units — for building structures. It could also be used in form of insulated walls, with the only other material being the wooden structural frame.

Hempcrete can also be used as prefabricated blocks and panels with higher density and lower thermal insulation. Particular attention must be paid to filling the gaps to avoid thermal bridges.



**Fig.2: Hemp brick**



**Fig.3: Hemp oil and varnish**

### **Hemp oils and varnishes**

Most natural buildings require more or less wood to protect them from mold and pests, and outdoor elements are not affected by the weather. In these situations, hemp is a very effective protection. Like the whole plant, hemp oil is extremely resistant to mold and can repel pests. It is easy to use, beautiful and durable.

**Fig.1 Hemp concrete**

### **Hemp fiber insulation**

Hemp fiber is bonded into sheets that be formed and cut into a variety of dimensions then installed as semi rigid “batts” between structural framing as a direct substitute to fiberglass and many other typical insulation materials. Hemp fiber insulation exhibits higher insulation performance (R-Value) but less other beneficial characteristics than Hempcrete in its typical application.

### **Hemp ropes and strands**

The rope is made of 100% hemp without artificial impurities. Ropes are manufactured in different diameters and have high strength. They are used in joints for installing windows and frames, sealing fillers in frames, sealing expansion joints, sealing dilatation joints, building and repairing houses, bridges, tunnels, wooden cottages, etc.

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<sup>4</sup> Nigel Isaacs, 2014, Hempcrete – An Environmentally Friendly Material

#### **IV. CONSTRUCTION OF HEMPCRETE**

Working with the hempcrete does not require special skill. When building the walls, the hemp concrete is most often squeezed into the formwork. When insulating the roof, it is rather looser, when the floor is finally wiped away, tightening. When plastering, it is classically cast, using a spray gun. For precise plasters it is worthwhile to sift and use only finer particles.

##### **Wall**

Hempcrete walls usually need a structural wooden frame, because they are not strong enough to support its load-bearing. Although they have some strength in compression, this is not enough in itself to support the weight of the roof and upper floors. The set hempcrete, though, does provide a good strength in tension, which provides racking strength to the timber frame, meaning that the use of timber can be minimized in a well-designed frame. It is perfectly possible to construct large buildings, including those with structural frames of glulam, steel or concrete to accommodate several storeys or cross large spans, using cast hempcrete. However, these are more likely to involve complicated frame designs, and in the case of very large buildings it is likely to be quicker and more cost-effective to use prefabricated hempcrete panels or blocks or sprayed cast-in-situ hempcrete than to place the hempcrete by hand.

Hempcrete could not only use for external walls of a house, but also could be used for internal walls. It could provide a good thermal and acoustic barrier between rooms and cast at a much-reduced thickness.

At the base of the walls, built on the foundations, is a plinth. The plinth has a damp-proof-course running (DPC) along the top of it. On top of the plinth and the DPC, the structural frame is constructed. The usual method is to build a simple studwork frame consisting of a floor plate, studs and a wall plate of untreated softwood timber. The frame is usually encased centrally within the cast hempcrete wall, but can be positioned flush with the surface of the hempcrete, either internally or externally, to make fixing into the wall easier.

##### **1. Central frame**

The position for the frame is often in the center of the hempcrete wall, because the structural timbers are well protected from moisture and insect attack. Another advantage is that the frame provides a more stable structural support to the hempcrete when placed centrally, since the weight of the hempcrete is evenly distributed around it.



**Fig.4: A softwood frame buried centrally in the wall is the standard design.**

## 2. Exposed frame

The structural frame can be placed flush with either the internal or external face of the wall. With this approach, because the weight of the hemcrete is not distributed evenly around the studs, there is the potential for the wall to fall away from the studs. For this reason, additional horizontal rails, usually of 50mm x 25mm roofing batten, are added to the frame, to provide a good key and lateral resistance for the hemcrete wall. These are fixed to the side of the stud that faces the interior of the wall, and run the whole length of the wall at 600mm vertical centers.



**Fig.5: Exposed frame internally for permanent shuttering, showing horizontal rails.**

### 3.Double frame

If external cladding and internal permanent shuttering board is necessary, we can use double-frame design. It contains an exposed frame flush with the internal face, which acts as the structural frame, into which the permanent shuttering is fixed, and a second, non-load-bearing frame flush with the external face to provide a fix for the cladding.

Afterward, we can open windows and door on the hempcrete walls. Hemp shiv (the chopped-up core of the hemp stem) is mixed with a binder in a forced-action pan mixer or a conventional bell concrete mixer, and transported by hand (it is relatively light) in tubs to be placed into the wall. The hempcrete mix should be quite dry and is tipped out of the tubs, rather than poured, before being distributed evenly with a gloved hand. It is important to make sure that the entire void is filled consistently, especially around intricate frame details, where small corners are often created between the frame and shuttering.<sup>5</sup>

### Floor

Hempcrete can be used as an insulating flooring. Comparing to the hempcrete wall, it has a higher density mix, for additional structural strength. The process of making the hempcrete is easier and quicker too, as you are spreading it on to the floor rather than placing it carefully in shuttering. The depth of the floor build-up for a hempcrete floor is usually less than is necessary for concrete floors, because both the sub-base and the main structural layer are insulating materials, meaning that less excavation is required, which has the potential to reduce costs, energy consumption and material to be removed from site.



**Fig.6: Hemp concrete walls and floors (by P. Majringer, Konopný-beton)**

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<sup>5</sup> William Stanwix and Alex Sparrow (2014), *The Hempcrete Book: Designing and Building with Hemp-Lime* (Sustainable Building)

## Ceiling

Hempcrete is also available for ceilings inside either flat or pitched roofs, or between floors where there is cast-in-situ hempcrete insulation directly above the ceiling. Hempcrete ceilings cannot cast without insulation. Rarely use of cast-in-situ hempcrete for downstairs internal ceilings and insulation between floors, because the extra expense is prohibitive, unless increased acoustic or thermal insulation is required between different parts of the building<sup>6</sup>.

## Roof

Hempcrete are also could be used as roof insulation. It is usually used in new build rather than old buildings. The thickness of hempcrete required enough depth for rafters, and the increasing depth of the total roof buildup in an old building will cause many problems such as changing the roof height externally, losing height from the inside of the room, even the increasing loading on the original structure by extra roof timbers. To be awareness, cannot provide load bearing, because the hempcrete roof insulation has very low density, in order to minimize weight and maximize insulation.



**Fig.7: Placing freshly mixed hempcrete into shuttering (William Stanwix & Alex Sparrow)**

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<sup>6</sup> Using hemp in construction (2016), <https://www.motherearthnews.com/green-homes/natural-building/hempcrete-ze0z1602zbay>



## **V. CONCLUSION**

It has been over a decade since the hemp material building had been constructed. As a new natural building material, hemp has obvious advantages than traditional building material. However, hand work is still the main method during the construction of hemp material building. With the popularization of prefabricated components, hemp will be applied in a wide range of projects, although it is a relatively new and low-profile material. According to its sustainable property and relatively low-tch construction method, it has a great future as building material for more and more common people to realize it huge potential.

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