

# Prospect of Sustainable Environment: A Case Study of Natural Building

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## ABSTRACT

Natural building is a promising reaction to the mentioned green-washing approach to sustainable construction. It consists in looking for alternative methods of construction which significantly reduce resource consumption, provide energy efficiency without causing pollution, damaging health and eco-systems.

Natural building represents attempts, particularly in rich developed countries, to substitute a much lower impact technology for that which is currently used. Its aim is to use materials and technologies which minimize the depletion of planetary resources and thus to reduce or eliminate dangerous and damaging materials such as cement and toxic chemicals.

## 1. Introduction

The introduction of hemp (*cannabis sativa* L.) is an agricultural crop that can be used as a building material in combination with lime and cement. A composite building material that combines a cementitious binder (building limes and cement) with hemp shives.

The woody core of the stalk is generally referred to as hemp concrete (HC)

Hemp Shives were first introduced in the early 1990s in France in order to lighten Concrete (Evrard 2006). Hemp concrete is the term describes building materials that combine a binder & shredded hemp.



Figure1. Hemp concrete

A hemp stalk can be separated into fibers. Located in the bark, and Shives located in the core of the hemp stalks. .hemp Shives are the woody core parts of hemp stalk.

Referring to their appearance and cellular structure, which resembles that wood? (Evrard, 2003). In the literature of a combination of a lime –based cementations binder and hemp shives has been referred to as hemp concrete (translated from France, Evrard, 2003), lime –hemp concrete.

At present, several products such as hemp shives and pre-mixed limes are readily available to create hemp concrete, there are many companies cross Asia, Europe & Africa market product mainly suited in France Hemp is a fast growing annual plant. It is a member of the family *cannabaceae* in the order Utricles' (which includes the nettle family). A hemp plant can

reach of a height of 1.5-4 m especially in northern Europe, while further south it can reach up to 10 m, Hemp fibers have high tensile strength, advantageous use in number of product

## 2. Historical Building Materials

Hemp concrete shows some similarities to other building materials and methods that have been used throughout history, including roman cement and half-timbering.

Roman cement is an ancient building material where a bonding agent such as lime is combined with pozzolans and fibrous organic material to improve tensile strength and prevent cracking of the material. This concept has been used and proven durable through time over the last millennia. Cato (234-149 B.C)

The mix that Cato described over 2 millennia ago combines lime, aggregate such as stone, earth and sand, and straw as fibrous organic material in mix with water. The use of

lime in building structures dates back even further than that. According to Adam (1994), lime was already used in Asia Minor in the sixth millennium B.C.



Figure. Half-timber house Sweden

Building method is that of half-timbering (Swedish), with a framework of timber and an infill of mud and straw, see figure 1. In Sweden this building technique was mainly used in Scania, a southern province with few forest. The wooden frameworks were load-bearing while the mud and straw created a wall that had reasonable thermal insulation properties and a high thermal mass. The straw improved the durability of Mud wall.

There are several similarities between Half-timbering and hemp concrete both have a load-bearing framework of timber, in combination with an infill of fibrous organic matter (straw and hemp)

### 3. Background

Housing and shelter in general is one of the basic human needs. Today, in global terms, developed countries use energy and resources to fuel their building industry that is wasteful and way beyond the ability of the planet to support such wasteful consumption.

Mass materials like cement and concrete cause significant pollution; use a lot of energy and non-renewable resources.

### 4. Natural Building

Natural building is a promising reaction to the mentioned green-washing approach to sustainable construction. It consists in looking for alternative methods of construction which significantly reduce resource consumption, provide

energy efficiency without causing pollution, damaging health and eco-systems.

This would play a key role in bringing construction in compliance with the four sustainability principles already mentioned. Natural building in fact, if managed in respect of those principles, could easily be taken as an example of sustainable development. Buildings are the most visible and tangible sign of economic development anywhere in the world; nature speaks for itself, indicating the use of materials and processes that is compatible with the functions of the natural world.

### 5. Past and Present in Natural Building

Natural building began with the work of enthusiast individuals who spent decades in understanding indigenous and low impact construction techniques, and in integrating these historic concepts into modern design standards of comfort, health, safety and durability (Elizabeth and Adams, 2000). It is important when adopting this approach to develop forms of construction, which are as good as, if not better than conventional building (Woolley, 2004).

Traditional and vernacular architecture is a source of inspiration for natural building. For this reason many people still view some of these techniques as turning the clock back (Woolley, 2006). Humans have evolved to live in contact with organic materials such as wood, wool and other fibers, and earth materials such as clay and lime. We can only benefit from them especially when employed to create shelter, which is

where we spend most of our existence. Today's natural building involves applying the knowledge and skills developed over the years, as well as by taking advantage of new

technologies, thus leading to a better quality of life. It consists in the opposite of reducing existing standards or returning back to the past.

Table 2.1 clearly compares the conventional and

| CONVENTIONAL BUILDING   | NATURAL BUILDING  |
|---|---|
| Uses non-renewable resources and materials  | Uses renewable materials which can be grown and provide cash to farmers   |
| Uses a lot of energy in extraction - high embodied energy   | Uses materials which need little energy to extract  |
| Significant transportation costs  | Should use local materials  |
| Extraction is often damaging and causes social problems   | Uses materials such as clay which is of low impact  |
| Many metals and other polluting materials are extracted and refined in poor countries and shipped to rich | Materials are extracted and processed locally   |
| Significant energy and chemicals are used to create energy efficient solutions                            | Generally little energy used  |
| External air pollution caused by manufacturing processes  | Virtually no external pollution   |
| Internal pollution due to the use of toxic additives like solvents  | Natural materials rarely cause health problems if handled properly and are not treated with toxic fire retardants, etc. |
| Waste manufacturing and installation is a normal part of processes  | Little waste if care is taken   |
| Damage to eco systems at end of life disposal   | End of life can be recycled or returned to the earth and decompose naturally  |

Source: Woolley, 2004

It is believed, by many people and professionals, that using green materials or technology is much more expensive than that standard. Oppositely, as confirmed by Woolley (2004), the aim of the natural building movement is for such materials to be as economical, if not cheaper than conventional, to be of a high standard and have a very good life cycle performance.

Natural building is still at a pioneering stage and it still requires many more efforts to demonstrate that the methods and materials used are going to be problem free, will be durable and meet the regulations. There is indeed a need for scientific research and changes in official regulation and standards. Another interesting aspect of natural building is its ability to be more attractive, create more beautiful and harmonious Buildings, and generally to make its occupants feel better.

In recent years there has been a growing interest in the relation between health and buildings. The emergences of the Sick Building Syndrome and the increase in such Health problems as allergies, medical hypersensitivity, and asthma have added urgency to the debate (Harris & Borer, 2005). The natural building movement can only benefit from this and attract the attention of the public opinion.

Given the choice between a cheap synthetic material, product or method of building and a natural one, people are generally aware that the natural option is better. There may be

awareness of the scientific and environmental reasons but not always an understanding of the technical detail. Intuition leads to the natural alternative.

Unfortunately the building industry is still very conservative and customers interested in using materials and methods often get plenty of hostile advices. Professionals themselves tend to stay away from building techniques that are not covered by a standard, an Agreement certificate, warranties and indemnity insurance (Woolley, 2006).

**6. Hemp**

The present work tries to analyses the prospect multi-story by lime-hemp, a particular building material and construction method that can definitely be classified among the natural building category. It is therefore necessary to provide the reader with an overview on what its core components are as well as their own singular properties.

**Introduction**

Hemp refers primarily to *Cannabis sativa* L., Cannabaceae family, although the term has been applied to dozens of species representing at least 22 genera, often prominent fiber crops (Small and Marcus, 2002). There are many pseudonyms for hemp, throughout history and in different languages. Hemp is a term that has also been used casually to describe other fibre plants such as Manila hemp and Sunni hemp. This can

and has lead to confusion both within and outside the academic community (Young, 2005).

*Cannabis sativa* is a multi-purpose plant that has been domesticated for bast fibre in the stem, a multi-purpose fixed oil in the seeds, and an intoxicating resin secreted by epidermal glands. The common names hemp and marijuana have been applied loosely to all three forms, although historically hemp has been used primarily for the fibre Cultigen and its fibre preparations, and marijuana for the drug cultigen and its drug preparations. The current hemp industry is making great efforts to point out that hemp is not marijuana.

Italicized, *Cannabis* refers to the biological name of the plant *Cannabis sativa* L., since only one species of this genus is commonly recognized. Non-italicized, cannabis is a Generic abstraction, widely used as a noun and adjective, and commonly often loosely used both for cannabis plants and/or any or all of the intoxicant preparations made from them (Small and Marcus, 2002).

**History of hemp in the world**

Cannabis, family *Cannabaceae*; species: *Cannabis indica*, *Cannabis ruderalia*, and *Cannabis sativa* L., has been found on every continent in this hemisphere, it was used long before its first recorded uses. It’s safe to believe, that no historian knows which peoples were first to experience her treasures.

In every society where people discovered Cannabis hemp, they often discovered the five uses for hemp which include; *hempen fibers, oil from the seeds, the seeds for food, a medicine, and for its narcotic properties.* Cannabis use has existed for over ten thousand years, and is one of the oldest crops used for cultivation. It was cultivated in China as early as 4000 BC. Most cultures viewed hemp as a gift, or treasure, from the Divine Sprit, to be used during ceremonials, at which time it was either burned as incense, ingested for deep meditative and heighten awareness, smoked for pleasure, or worn for clothing during these ceremonies.

Hemp has been mentioned in many important documents over its recorded history, The *Zend-Avesta*, a sacred book used by the peoples of India dating back to 600 BC, spoke of hemp’s intoxicating resin. The Chinese emperor and herbalist, Chen-Nung wrote about hemp’s medicinal uses 5000 years ago, his pharmacoepia recorded its effects on malaria, female disorders, and many other illnesses, hemp was referred to as, *Ma-fen* “hemp fruit”, said; “if taken in excess, will produce

hallucinations”. The *Anatomy of Melancholy*, published in 1621 recommended hemp for depression. The *New English Dispensatory*, of 1764 suggested applying hemp roots to the skin for inflammation.

In Africa hemp was used for dysentery, and fevers, today some tribes use hemp to treat snake bites, and women smoke it before childbirth. During the seventeenth century peasants believed in the magical power of hemp, and practiced their traditions. On Saint John’s Eve, farmers would pick flowers from their hemp plants and feed them to their livestock to protect the animals from evil and sickness.

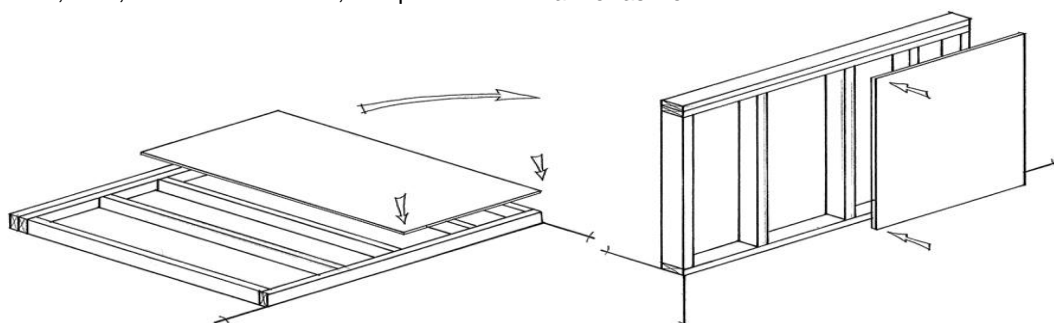
A western physician by the name of W.B. O’Shaughnessy published in 1839 of the benefits of cannabis for the treatment of rabies, rheumatism, epilepsy, and tetanus. He also reported that a tincture of hemp and alcohol taken orally was found an effective analgesic.

Henry VIII required the cultivation of one quarter acre of hemp for every sixty acres of land under tillage,

**Construction method**

The framing of walls, floors and roofs for the use of hempcrete follow the same procedure as typical wood framing. Excellent resources are available to guide builders through the process of building code-compliant framing (see Resources).For floor and roof framing, there will be no difference in procedure when using hempcrete insulation, assuming the framing dimensions have been specified to handle the dead load of the hempcrete insulation. Procedures for framed walls will vary based on the style of frame wall being used (see Design Options chapter). Frame walls are typically laid out and assembled on the floor deck of the building.

In conventional construction, structural sheathing is often affixed to the wall frames while they are lying on the floor as a timesaving measure, since it is easier to place large, heavy sheets of sheathing in this orientation, rather than having to lift, hold and fasten them vertically once the wall has been raised. The installed sheathing also keeps the wall frame square while it’s being raised; eliminating the process of squaring the wall after it has been raised. Cutting out window and door openings in the sheathing is also easier while the wall is horizontal. Whenever permanent sheathing is used one hemp Crete wall, it is best to install it while the wall is horizontal. In some cases, it may be faster and easier to install temporary formwork in this manner as well.



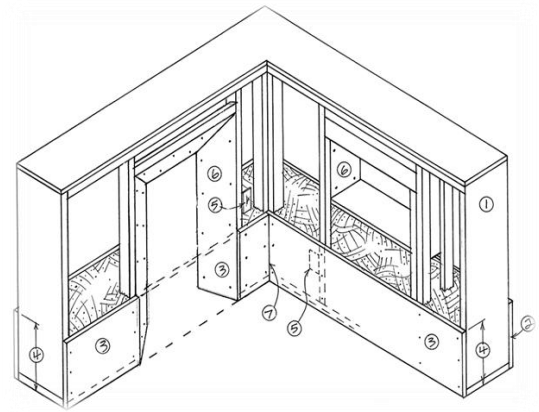
**Figure 3Method Steps construction**

Once the framing has been completed and the type of formwork has been chosen, the process of installing the hemp Crete is ready to begin.

1. Install as much formwork as is practical prior to mixing hemp Crete.

It is best to take care of trickier areas like window openings before starting to install hempcrete, as custom cutting and fitting of forms in these places takes time that could slow down the installation.

1. Wall, framed as per plans.
2. Exterior form. Can be full height of wall or slip form. One complete round of formwork should be fastened before hemp Crete mixing begins.
3. Interior slip form. One complete round of formwork should be fastened before hemp Crete mixing begins. Run form boards across openings to minimize cutting.
4. Height for slip forms is typically 24 inches (600mm). This can be achieved by ripping a typical 4foot wide sheet material in half, and is a comfortable reach for installers and tampers.
5. Any electrical boxes or other services and penetrations in the wall will need to be cut out of the form boards. This can be a time consuming process.



**Construction method frame/timber within it hemp Crete**

1. Formwork should be placed around the top and sides of all door and window framing. Leave the sill open to facilitate loading hemp Crete from above. Flared, angled or curved openings will take extra time to form. Avoid having this formwork protrude beyond the face of the wall to avoid interfering with slip forms when they are placed in these areas.
2. Interior and exterior corners require secure attachment for forms, especially when centered framing and spacers are being used.



Figure 4 Construction methods step by step



Figure 5- Lime-hemp mix



Figure 6 Lime-hemp on a timber frame



Figure7 Hemp Crete home or house

### Hemp Crete Properties

Listed below are the basic material properties

- Density: 93.6 to 136.4 Kgs/M<sup>3</sup>
- Compressive strength: 116 to 145 pounds Per square inch (PSI)
- Flexural strength: 44 to 58 PSI
- Fire rating: approximately 1 hour per 100 Mm of thickness
- RSI-value: .28/200mm to .14/500mm thickness available
- Air permeability: 1.0 x 10<sup>-6</sup> PSI
- Vapor permeability: 3.4 x 10<sup>-5</sup> PSI
- Binder: hydrated air lime blended with selected cementations, hydraulic and inorganic materials.
- Water: for mixing and curing

### Hemp Crete Benefits

The use of Hemp Crete as a building material can have the following benefits:

- Non-toxic
- No off-gassing
- No solvents
- Mold resistance
- High vapor permeability
- Humidity control
- Durable
- Sustainable
- Carbon sequestration
- Fire and pest resistance
- Passive self regulation of temperature

### 7. Conclusion

- Carbon capture: 108kg/M<sup>3</sup>
- Achievable air tightness: <1.1 cubic feet Per minute
- Acoustic absorption: 0.69 noise reduction Coefficient (NRC)

### Hemp Crete Material

Hemp Crete is a lightweight bio-composite building material made from industrial hemp stems, a lime based binder, and water.

- Aggregate: Hemp shi (the woody stem/core of the hemp plant)

Advocates of building with hemp Crete need to remember that this material is not the single solution to all of the world's problems either. It's an insulation material, and it must be incorporated into well-designed and well-made buildings in order for its benefits to be meaningful. Like all building materials, it has limitations and drawbacks, and we should be open and honest about these when promoting the idea. It's easy to fall into the realm of 2G2BT — Too Good to Be True. It is a disservice to potential designers, builders and homeowners if they are not given the full picture.

There are enough positive aspects to building with hemp Crete that it makes an attractive choice even when its limitations are made clear. As a builder, I am excited by the ease with which hemp Crete can be incorporated into any builder's style of construction. It is rare that an ecologically friendly alternative fits so well into the existing methods of building. For this reason, I am hopeful that more builders will be willing to adopt this material into their "toolbox" of options.

There is something very satisfying about standing back and looking at a newly for medhempcrete wall. I would also find it very satisfying to stand back and look at hundreds or even

thousands of new hemp Crete homes! The goal of environmentally conscious building design is to create buildings that create a healthy indoor environment while supporting a healthy outdoor environment. The best way to accomplish this goal is through combining cutting-edge building science with what are commonly called “natural building” practices. High performance building science allows us to create buildings that use almost no energy to run, therefore reducing the size and price of the renewable energy system required to produce on site all the energy required to run the building. The natural building perspective helps us utilize natural, local, and site harvested materials that have a very low embodied energy,

therefore lowering the carbon and pollution footprint of the building during construction. Together, these two strategies allow us to reach the threshold of carbon neutrality, a building that does not contribute to our current climate change problems. On the natural building side, we feel that earthen mixes don't have adequate thermal performance while the vulnerability of straw bales to water damage concerns us. On the high-performance commercial side, we are skeptical of the long-term durability of SIPS walls and feel that double stick frame systems are too complex and prone to air infiltration weaknesses. These and other problems have been solved by what to us is a new material: Hempcrete.

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