

Building on a Sustainable

"High"

The use of Hemp as A Sustainable Building Material

Luyen Pillay

Building on a Sustainable “High”:

The use of Hemp as a sustainable building material.

By: Luyen Pillay

28173105

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Faculty of Engineering, Built Environment and Information Technology

Department of Construction Economics



Study Leader

Mr. HJ Cruywagen

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Declaration by Student

I the undersigned hereby confirm that the attached treatise is my own work and that any sources are adequately acknowledged in the text and listed in the bibliography

Signature of acceptance and confirmation by student

Abstract

Title of Thesis:

Building on a Sustainable "High":
The use of Hemp as a Sustainable
Building Material.

Name of Author:

Mr Luyen Pillay

Name of study leader:

Mnr JH Cruywagen

Institution:

Faculty of Engineering, Built Environ-
ment and Information Technology, De-
partment of
Construction Economics. University of
Pretoria

Date:

October 2012

In a world currently finding itself in a dire state due global warming and pollution, industries, institutions and the general public are continuously seeking newer methods of sustainable and environmentally friendly ways of living and operating. Could the solution to this predicament, specific to the construction industry, be found in a plant that has existed around the world for millions of years? This research report will attempt to answer such a question by taking into consideration the cultivation of hemp and how it is beneficial to the environment, the type of building materials manufactured from hemp (hempcrete and hemp bricks/blocks), the science of why hemp is sustainable, possible finishes and alternative innovation and lastly the impact of hemp construction in South Africa and whether it is feasible to construct using hemp or not at this current point in time. The South African legislation and perception of hemp amongst the public and professionals shall furthermore be explored in addition to the country's first hemp home constructed in November 2011.

Table of Contents:

<u>Chapter 1: Introduction</u>	1
1.1 Overview of the Topic	1
1.2 The History of Hemp: Taking it back over the Centuries	2
1.3 Hemp: The Crop	5
1.4 The Main Problem	9
<u>1.5 The Sub Problems:</u>	9
1.5.1 What makes hemp construction possible and what methods are required	9
1.5.2 What is the science behind hemp construction its sustainability factors and design principles	9
1.5.3 What finishes and other products of hemp are available	10
1.5.4 Is there a relationship between the economical factors of hemp construction and the South African legislation regarding Cannabis in addition to the general perception of hemp	10
1.6 Delimitation	10
1.7 Definitions of terms	11
1.9 Importance of the study	12
1.11 Research Methodology	13
<u>Chapter 2:What makes hemp construction Possible and what methods are required?</u>	
2.1 Hempcrete	14
2.2 Hemp Bricks and Blocks	18
2.3 Hemp Panels and Pre Fabrication	20
2.4 Plant ,Tools Equipment and Methods of Construction	21
2.5 Application of Hempcrete	24
2.6 Summary and Conclusion	26
2.7 Hypothesis	26

Chapter 3: What is the science behind hemp construction its sustainability factors and design principles

3.1 Introduction	27
3.2 Practical Tests Undertaken in the past	27
3.3 Resistance	32
3.4 Inhabitable Experience	35
3.5 Design	37
3.6 Summary and Conclusion	41
3.7 Hypothesis	42

Chapter 4: What finishes and other products of hemp are available

4.1 Introduction	44
4.2 Hemp Plaster	44
4.3 Other Types of Finishes	50
4.4 Other Products available	52
4.5 Summary and Conclusion	53
4.6 Hypothesis	53

Chapter 5: Is there a relationship between the economical factors of hemp construction and the South African legislation regarding Cannabis in addition to the general perception of hemp

5.1 Introduction	54
5.2 Hemp Industry in South Africa	54
5.3 Perceptions of Hemp in South Africa	57
5.4 South Africa's first hemp home the; most sustainable home in the country	59
5.5 Summary and Conclusion	63
5.6 Hypothesis	64

Chapter 6; Conclusion

6.1 Introduction	65
6.2 What makes hemp construction possible and what methods are required	65
6.3 What is the science behind hemp construction its sustainability factors and design principles	66
6.4 What finishes and other products of hemp are available	67
6.5 Is there a relationship between the economical factors of hemp construction and the South African legislation regarding Cannabis in addition to the general perception of hemp	67
6.6 Further Research Suggestions	68
6.7 Final Conclusion	69

<u>Bibliography:</u>	70
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List of Figures

<u>Figure 1</u>	Hemp Blocks	19
<u>Figure 2</u>	Spray on application of hempcrete	24
<u>Figure 3</u>	Typical uses of hempcrete on a house	25
<u>Figure 4</u>	Hempcrete applied as a roof by using of shutter boards	25
<u>Figure 5</u>	Window aperture applications	25
<u>Figure 6</u>	Thermographic image of house constructed using ma- sonry	29
<u>Figure 7</u>	Thermographic image of hemp house	29
<u>Figure 8</u>	Resistance to fire after 1 minute	34
<u>Figure 9</u>	Resistance to fire after 5 minutes	34
<u>Figure 10</u>	Resistance to fire after 7 minutes	34
<u>Figure 11</u>	Capacity	35
<u>Figure 12</u>	Inertia	35
<u>Figure 13</u>	Light weight stud wall frame design	43
<u>Figure 14</u>	different types of textures of hemp plaster	49
<u>Figure 15</u>	Hemp imports and exports in S.A	55
<u>Figure 16</u>	“Fabulous Furry Freak Brothers”	56
<u>Figure 17</u>	Results obtained from Facebook questionnaire	57
<u>Figure 18</u>	Professionals Questionnaire results	58
<u>Figure 19</u>	South Africa’s first hemp home during construction	62
<u>Figure 20</u>	Orientated to achieve maximum benefit of natural heat- ing and light.	62
<u>Figure 21</u>	Interior and exterior views	62

Chapter 1

Introduction:

How and when did the use of hemp begin?

1.1) Overview of the topic:

Cannabis sativa, otherwise known as hemp has become a highly sustainable building material over the past few years, and has just recently been introduced in South Africa. The country's first hemp home was constructed in November 2011 and has already been dubbed the most sustainable home in the land. **(Laylin, 2011).**

The hemp product used for constructing such homes is generally known as hempcrete. Hempcrete is produced by processing the stems of the hemp plant which yields two materials namely; hurds and fibres. These two materials are the key aspects of the plant's building qualities. Once the hurds are obtained they are mixed with various lime based products according to the type of construction applicable in addition to the climatic aspects of the region. The hempcrete cannot stand on its own and therefore a timber frame is needed to hold it in place. This can be achieved in one of two ways, either by process known as tamping down between shutter boards or by a spray-on application where the product is sprayed onto formwork which maybe permanent or temporary according to the design and specifications. Once the application of the hempcrete has been accomplished a range of finishes are available. In most cases external hempcrete is finished by making use of a lime render painted over with a coat of breathable natural paint.

(<http://www.hempbuilding.com> 2012)

Another hemp based building material is in the form of a brick commonly known as a hemp brick. A hemp brick consists of the same ingredients as hempcrete; the only difference being that pozzolans or cement is added to the mixture and it is cast into the shape of a brick. The brick has a general strength of approximately 1 Mpa and is flexible, unlike conventional bricks; therefore the need for expansion joints are eliminated. **(<http://www.organicworld.com> 2012)**

According to (<http://www.hempbuilding.com> 2012) some of the advantages of hemp construction include:

- The fact that hemp is a natural plant and is renewable
- The energy used in producing hempcrete is relatively low
- Hempcrete is fire proof, rodent proof and water resistant
- Excellent insulation properties
- Excellent sound proofing qualities.

1.2) The History of Hemp: Taking it back over the Centuries:

1.2.1)8000 BC:

Over 8000 years ago hemp was regarded as the world's most popular and versatile agricultural crop and hence the mainstream producer of the world's paper, fibre, fabric, oil, medicine and protein for the use of both humans and animals alike.

(www.hemporium.com 2012)

Unfortunately over the last century this robust plant has been associated with its narcotic cousin marijuana and viewed as negative due to the effects of THC (Tetra Hydro Cannibol) and hence has been banned from many countries including South Africa. (www.hemporium.com 2012)

According to research conducted by the *Columbia History of the World* the world's first woven fabrics were manufactured by making use of hemp.

(www.hemporium.com 2012)

1.2.2) 2800 BC:

The origin of hemp, according to historical evidence, is said to be situated in central Asia specifically between the Himalayas and Siberia. Hems worldwide expansion was due to the migration of man. China now houses the most varieties of hemp. In 2800 BC Emperor Shen Nung educated the Chinese population of how to cultivate hemp for its fibre. There is no doubt that this had an impact on the use of hemp in construction today. It is even said that Buddha (an Asian deity) consumed a single hemp seed every day on his path to enlightenment (www.hemporium.com 2012)

Hemp was primarily used in Europe around 450BC by the Thracians and Scythians. The Scythians are believed to be the predominant force that introduced hemp to Europe during their westward movement in 1500BC. Today this fact is extremely vital as Europe is one of the major continents in the world that widely uses hemp in the construction of sustainable houses. (www.hemporium.com 2012)

1.2.3) 100AD:

It was during this era that hemp was given the name Cannabis sativa by a Roman Surgeon by the name of Dioscorides who frequently made use of the plants' medicinal benefits. Simultaneously a manual was written about the farming methods and the plants' industrial uses including building by an author by the name of Pliny. .

(www.hemporium.com 2012)

The plant then spread to Japan where it was used in the manufacturing of clothing and food sources. (www.hemporium.com 2012)

1.2.4) 1500s:

During the 1500s hemp began to spread vastly around the world including countries such as North and South America as well as Australia. It was used mainly for food, clothing and fuel purposes. In North America particularly hemp was accepted as a legal tender and a tax even applied to it. Hemp had become such a vital crop that George Washington urged farmers to grow the crop; the plant was also regarded as a 'necessity' by Thomas Jefferson. It is also known that the American Declaration of Independence was drafted on hemp paper in addition to the first pair of Levi jeans being manufactured out of hemp fabric. . (www.hemporium.com 2012)

1.2.5) 1930s:

Hemp continued to flourish throughout 1800s until the mid 1900s where its demand diminished due to the new discovery of other tropical fibres, the invention of steam ships and lesser use of sails which contained hemp and the petrochemical age as well as other chemicals which aided in extracting wood pulp from trees to manufacture paper and lead to the decline in the use of hemp paper. .

(www.hemporium.com 2012)

The hemp industry soon found itself in dire straits in the 1930s when a machine was invented which extracted the fibre and converted hurds into paper. This invention immediately drew the attention and sparked fury and worry into the minds of synthetic fibre producers along with the cotton and paper industry as they alleged that they could stand to lose billions of dollars if hemp was exploited to its full potential. These industries were largely responsible for the “reefer madness” propaganda campaign, which led to the outlawing of hemp and thus the elimination of hemp competition. The “reefer madness” propaganda campaign effectively persisted and succeeded in outlawing narcotic marijuana and in turn this led to the abolishment of the entire cannabis family. This was a highly unfortunate event as Henry Ford, at that specific time, constructed a car which consisted of a body made of hemp composites in addition to running on hemp fuel. The advancement of petrochemicals led to the downfall of hemp based fuel. The planet's current environmental situation is suffering due to this advancement and the rising cost of fuel speaks for itself, hemp based fuel would have provided a more eco friendly as well as an economically cheaper solution as hemp is a renewable source. . (www.hemporium.com 2012)

1.2.6) 1955:

During the Second World War the Japanese cut off supplies of Manila hemp to the USA which was used in the fabrication of army uniforms and rope. It was due to this that the American legislation changed its tune and farmers were once again urged to grow hemp however this was short lived as in 1955 the crop was once again banned and remains so in the States until today. (www.hemporium.com 2012)

1.2.7) Today:

Many countries, including South Africa, have adopted the United States legislation regarding the abolishment of hemp. Both the United States and South Africa make no distinction between hemp and its narcotic cousin marijuana. In this day and age however numerous countries such as Canada England and France are beginning to establish legal hemp industries and apply it to their construction industries as they realise the importance of sustainable living and the impact that hemp can have. Hemp may not only provide a solution to sustainable living but it may also provide alternative solutions to war generation and polluting petrochemicals as well as de-

forestation caused by paper production. Hemp is believed to be the only renewable resource which can meet the demands of environmentally friendly living of the 21st century. (www.hemporium.com 2012)

1.3) Hemp: The Crop

1.3.1) Botany:

The species Cannabis is principally categorised into three sub-species namely:

- 1) **Sativa:** consists of all hemp and mostly marijuana, primary use for seed sowing
 - 2) **Indica:** known for its psychoactive response, predominantly thrives in the Himalayas specifically on the Indian side
 - 3) **Ruderalis:** is adapted to grow in short seasons, programmed to flower after a definite period, predominantly flourishes in Russia
- (Allin, 2012)

A hemp plant grown on an annual basis may reach a height of 3 to 5.4 metres however the plants usually reach a common height of 1.8 to 2.1 metres as the crops are grown within close proximity of one another. The leaves of the plant mature across from one another in a hollow stem. Once the plant reaches maturity the hollow stems fills up with a woody core and the fibres in the bast (hurds) strengthen. This process is necessary in order to support the seed head. The seeds in a ripening head are viewed more as nuts than seeds as they consist of a kernel encased by a shell. (Allin, 2012)

1.3.2) Cultivation:

The materials desired to be produced by the hemp plant is dependent on the manner in which it is grown. Seeds are planted one meter apart in order to obtain a plant consisting of a lengthy and brawny fibre, as needed for construction. A crop that is more densely grown will result in shorter and finer fibres suitable for hemp plaster. In most climates the seeds are sown just after winter, April in the Northern Hemisphere and around September in the Southern Hemisphere, in order to miss the last traces

of damaging frost. The young seedlings penetrate through the earth's surface just after the first week, there after they grow at a dynamic rate of 100-300mm a week during the second and third month's respectively. It is highly important that the soil be prepared correctly before planting begins, if this is achieved no further obligations need be fulfilled toward the soil until the crop is ready for harvesting. The soil needs to be meticulously tilled in order to achieve an even germination in addition to this the soil needs to be rolled after each seed is sown. This process is executed to ensure that the crop is harvested as close to the ground as possible in order to avoid damage to harvesting machinery **(Allin, 2012)**

If a hemp plant is grown for its seed purpose, the plants are grown individually 0.5 to 1 meter apart in order for the branches to grow high up into the light and ensure that the seed heads develop and mature to their full seedy potential. **(Allin, 2012)**

1.3.3) Harvesting:

The appropriate time for harvesting is dependent on the application of the hemp. If a fine soft fibre is required harvesting should take place once the plant begins to flower. If seeds and stronger fibre are required then the plant should be harvested once the seed heads have reached maturity. Modern and traditional methods of harvesting are both applied during this day and age, traditional methods include the use of finger bar mowers while more modern techniques make use of disc and drum mowers which hastily make their way around a field leaving the stalks behind in sways ready for a round baler to pick up and bale. In countries experiencing unpredictable weather it is best to remove the leaves, which contain excess water that may cause future problems, before harvesting the stalks. The leaves can either be used for fragrance extraction or returned to the ground in order to create compost. **(Allin, 2012)**

1.3.4) Processing:

The process of removing the cortex or skin of hemp is commonly known as decortication and was traditionally accomplished by hand until the invention of machinery. The fact that hemp contains the longest and strongest fibres amongst all plant species made this task a complex one. During many processors the fibres would wrap around the rotating parts of the machinery leading to their destruction. Slower proc-

essing of the crop yields a material suitable for the spinning industry whilst faster processing produces fibres fit for the use in reinforcing panels in the automotive industry, insulation panels for construction and speciality paper. The eventual goal will be to harvest the crop and process the stalks simultaneously however this process is far in the future of becoming a reality. **(Allin, 2012)**

Start Hemp a company based in France has invented a mobile machine that produces a continuous ribbon of combed aligned fibre known as "sliver" which is immediately ready for further processing in textile machinery. Today the largest hemp processors are situated in Europe in countries such as England, France and the Netherlands. The longest known processor is *La Chanvrie'ré de L' Aube* which is situated in France and has been in constant operation since 1973. This company has the capacity of producing 6000 hectares of hemp per season. A new hemp processing facility has recently been established in Australia and focuses on developing seeds suitable for the district. **(Allin, 2012)**

1.3.5) Environmental Impact:

Organic agriculture is an ever so present issue and hemp may play an extremely vital role in this matter. Producing a maximum yield is dependent on controlling the amount of weeds found in the same soil as the crops; most farmers make use of chemical herbicides and fertilizers to eradicate this problem. As a hemp plantation grows it provides sufficient shade which enables fewer weed seeds to germinate in the preceding year after the current harvest. An additional advantage of maturing hemp plants is their ability to shed their leaves, these falling leaves form a debris on the surface of the ground and in turn decompose and replace up to 40% of the nutrients consumed by the growing the hemp plants. After the harvesting of a hemp plantation an alternative crop such as wheat can be planted on the same ground and the result will be a yield of between 10-20% compared to planting on normal wheat fields. This process will maximise the production of such food stuffs and in turn will aid producers in meeting the demands of the worlds growing population. **(Allin, 2012)**

There is no doubt that the growing of hemp is beneficial to the environment. With regards to building materials hemp replaces conventional building materials in which the production is unsustainable in addition to the extraction of minerals, as in the

production of steel, which is also rendered unsustainable and non renewable. **(Allin, 2012)**

Even if hemp is not grown under organic conditions it is still highly advantageous to the environment as no herbicides or pesticides are required at all. The shading of the ground as mentioned before also aids in keeping the ground cool and thus preventing it from drying out. Whilst harvesting a significant portion of the root is left behind, this is advantageous in two perspectives; firstly it holds the soil together and secondly it acts as a pipe and provides aeration to the soil. The seed of a hemp plant assists in attracting songbirds this is beneficial to the crop as the bird leaves behind rich manure as they feed. The use of low energy and non toxic additives in the production of hemp products adds to a low negative environmental impact. **(Allin, 2012)**

1.3.6) Hemp Hurds:

In construction the most vital element of a hemp plant is the wood like core found in the stem known as hurds. The most important aspects of this particle include its form quality and size; these aspects all play a vital role when mixed with other ingredients to produce the building material. The plants are best harvested once they have reached a mature state due to the fact that the hurds are firmer and able to withstand larger amounts of compression. The method and type of machinery used in the decorticating process will determine the size and proportions of particles. The type of application of the building materials is dependent on the type of particles; longer particles provide a greater lateral strength whilst smaller particles provide a more dense material for the use in hemp plaster for example. It is highly important that the hemp hurds be free from any damage and retting in addition to contamination from foreign matter. Shipments of hemp hurds have in the past been confiscated at customs solely on the belief that the shipment contained enough THC to be classified as illegal despite the fact that the crop was grown from an entirely legal THC seed. **(Allin, 2012)**

1.4) The Main Problem:

Will hemp building be sustainable and economical at the same time?

1.5) Statements of sub- problems:

1.5.1) What makes hemp construction possible and what methods are required?

- ❖ Hempcrete
- ❖ Hemp bricks and blocks
- ❖ Hemp panels and pre fabrication
- ❖ What tools and equipment are needed for construction
- ❖ Hypothesis:

Like any trade in the building industry skilled labour will be needed although semi skilled labour will adapt to the skills fairly quickly as it is much similar to convention methods such as the case of applying shotcrete.

1.5.2) What is the science behind hemp construction, its sustainable factors and design principles?

- ❖ Previous research
- ❖ Strength and stability
- ❖ Thermal Properties
- ❖ Acoustic Properties
- ❖ The wastage factor
- ❖ Resistance to fire and water
- ❖ Living experiences
- ❖ Design principles
- ❖ Hypothesis

Hemp construction has been proven to be highly sustainable with excellent thermal and insulation properties. There are a variety of different designs available.

1.5.3). What finishes are available and other products of hemp are available:

- ❖ Painted
- ❖ Hemp plaster
- ❖ Hemp particle boards
- ❖ Hemp carpets
- ❖ External boarding
- ❖ Hypothesis:

The use of hemp is not only limited for the use as a structural building material and can also be use to achieve a variety of finishes

1.5.4) Is there a relationship between the economical factors of hemp building and the South African legislation regarding Cannabis and hemp based products in addition to the general perception of hemp?

- ❖ Hemp Industry in South Africa
- ❖ What does the legislation say about cannabis?
- ❖ What is the public's perception on hemp?
- ❖ How is the cost affected by legislation and perception?
- ❖ How can we distinguish between hemp products and the THC narcotic "drug"
- ❖ South Africa's first hemp home
- ❖ Hypothesis

South Africa needs to become more aware of the use of hemp and stop regarding it as a narcotic drug. If hemp is grown more intensively in South Africa the cost of importing hemp will be cheaper and hence cheaper building costs

1.6) Delimitations:

This research report is limited to the use of hemp as a sustainable building material. Other uses of hemp such as hemp fuels for motor cars, food sources, medicinal purposes, clothing as well as fragrance and cosmetic purposes shall be vaguely mentioned but not discussed in full detail. The costs associated with construction as well as maintenance costs shall be discussed in full. Research conducted will not only be limited to the impact of hemp building in South Africa but also around various parts of

the world specifically to regions experiencing similar climatic conditions as South Africa. Research regarding construction materials will be limited to residential and industrial use specifically.

1.7) Definitions of terms:

- ✿ **Hemp:** refers to Cannabis sativa, cultivated for its industrial use contains very small or no amounts of THC and has no physical or psychological side effects.
- ✿ **Retting:** the process of draining the hemp plant of excess water.
- ✿ **Decortication:** The process of removing the cortex or skin of a hemp plant in order to be used for industrial purposes.
- ✿ **Hurds:** wood like core found inside side the stem of the hemp plant. Very high in strong fibre, also known as **bast**.
- ✿ **Marijuana:** type of drug, illegal in many countries made from dries flowers and leaves of hemp plant. Contains enough THC to produce physical and psychological effects.

1.8) Abbreviations:

- ✿ **THC :** Tetra Hydra Cannibol
- ✿ **S.A.N.S:** South African National Standards
- ✿ **I.H.B.A:** International Hemp Building Association
- ✿ **CO²:** Carbon Dioxide
- ✿ **S.I.V.A:** Sustainable and Integrated Villages for Agro Ecology
- ✿ **B.R.E;** British Research Establishment
- ✿ **A.R.C:** Agricultural Research Centre

✿ **D.A.F.F:** Department of Agriculture Forestry and Fisheries.

✿ **V.O.C:** Volatile Organic Compounds

✿ **L.E.D:** Light emitting diode

1.9) Importance of the Study

In this day and age green house gasses, pollution and climate change play a vital role in our everyday lives with everyone seeking to live a more sustainable and “green” lifestyle. What people do not realise is that a possible solution to this life style has been around for centuries, in the form of hemp. In this research report the desire is to exploit the use of hemp to its fullest potential in the construction industry in addition to bring about a realisation of the sustainable benefits of hemp homes in South Africa by referring to the countries first hemp home . The only way in which hemp can be recognised in South Africa can be found in the decriminalisation of narcotic marijuana therefore creating a leniency of non-narcotic hemp. An additional aim of this report is to hopefully introduce the use of hemp as a sustainable building material into the Building Science subject offered to junior students studying in the fields Quantity Surveying, Construction Management and Real Estate in the Department of Construction Economics at the University of Pretoria. Another vital aspect of this report entails the awareness of hemp by recognising it as a plant with much potential not only related to the construction industry but also to the paper, textile and petrochemical industries and not as a narcotic drug

1.10) Conclusion:

From statements mentioned earlier in this chapter it is clear that hemp is an extremely versatile, robust and highly renewable plant that has been around for many centuries. There is no doubt that the use of this crop has benefited man from 8000 years ago up until the early 1900s. If it was not for the “corporate sabotage” by the petro chemicals and paper textile industries this robust crop would have indeed played a vital role in developing the world as we see it today, however the question of would the impact of hemp usage in all its forms been enough to prevent pollution and global warming shall remain a mystery.

1.11) Research methodology:

All research and information obtained shall be retrieved from the following sources:

- The world wide web, various internet web sites
- A book entitled “Building with Hemp” second edition 2012 by author Steve Al-
lin.
- Articles obtained from the internet and BRE
- Questionnaires sent out to contactors and other built environment profession-
als
- The South African legislation regarding the use of hemp shall also be referred
to in this research report from information retrieved from **D.A.F.F**

Chapter 2

What makes hemp construction possible and what methods are required?

2.1) Hempcrete:

2.1.1) The history behind hempcrete:

The history of the product known as hempcrete can be traced back to the city of Troyes in the Champagne region of France. This city consisted of various buildings constructed from oak frames in filled with straw, lime and rubble mix. A lime render was used to cover the infill however during renovation in later years a cement render was used. This posed a big problem in the fact that the walls could no longer breathe and hence the build up of moisture resulted in swelling and crumbling of the infill. This unforeseen problem caught the attention of an extremely imaginative artisan by the name of *Charles Rasetti* and who happens to be the man solely responsible for the idea of using hemp hurds as an additive to the infill. Charles first implemented his idea on a house commonly known as *The House of Turk* also situated in the Champagne region of France during a renovation process. Fortunately for Charles at that specific time hemp was going through a revival stage and the idea was soon adopted by three other artisans namely; *Bernard Boyeux*, *France Perier* and *Yves Kuhn*. All three of these artisans experimented by adding different binders to the infill thus creating their own versions of hempcrete. Boyeux, founder of Association Construire en Chanvre, and Kuhn, founder of Association ADAM, are still involved in the promotion of the material up to this day. The use of hemp the restoration perspective of old buildings has rapidly spread throughout France since the late 1900s until today. (Allin, 2012)

In the town of Angers, France stands a building known as *La Maison d'Adam* and dates back to the late 15th century. In 1995 a project entailed the refurbishment of the building was under taken. The building consists of a classic oak frame and infill of the time and stands six stories high. The ancient and repaired cement infill was

removed and replaced with hempcrete which was supplied by *Isochanvre*. Today the building still stands and its appearance is as good as it was in the 15th century only difference being that the infill is more breathable and less susceptible to damage caused by moisture. (Allin, 2012)

2.1.2) Additives:

In order to achieve a superior quality of hempcrete the hemp hurds are required to be mixed with certain additives, these additives include sand, water, lime or cement. (www.hemphesis.co.za 2012)

2.1.2.1) What makes the use of lime more important than the use of cement in hempcrete?

Lime is generally classified as a sedimentary rock and has been used for many centuries as a construction material; however the use of lime declined drastically owing the strength and stability of modern structures becoming an issue. On the contrary lime is starting to make slight come back in the use of today's construction materials as people seek to use more natural, sustainable and breathable material for construction. In addition to this lime is also beginning to be favoured over cement due to the fact that the energy used in cements manufacturing process has become expensive. (Allin, 2012)

The answer to the question posed above is as follows; firstly lime consists of minute pieces of burnt, crushed shells, as these shells are burnt porous sponge like particles are left behind as a result of the carbon dioxide gas being released. Larger particles float in a sea of smaller particles and reabsorb carbon dioxide, during this process, known as colloid, they bond together creating a mass. Not all of the particles have the ability to bond and thus remain "unmarried" and continue to move around the material. When this mass is present in hempcrete it sets and creates an extremely porous structure which has the ability to retain vast amounts of water as well as the ability to release it with the same amount of ease. However the free roaming "unmarried" particles play the most vital role in which they bond into the hemp particles thus coating the inner structure of the cellulose contained within the hurds. Over a number of years these particles substitute the cellulose thus fossilizing the material. The hempcrete continues to get stronger and harder each day until fos-

silization is reached. Another advantage of these free roaming particles is their ability to create a process known as *autogeneous healing*; during this process the free roaming particles deposit themselves into small cracks, which may appear in the lime based material, and healing the material. **(Allin, 2012)**

To further explain the differences between lime and cement, the manufacturing process of the two products needs to be explored. Both processes entail the burning of limestone, in the case of cement the limestone is burned at 1200-1280 degrees Celsius and is mixed with clay rocks which contain iron oxides whereas the limestone is burnt at a lower 900-1100 degrees Celsius in the fabrication of lime. The higher temperature in cement manufacturing is essential in vitrifying the lime in order to form nodules of clinker. These nodules of clinker are then ground into a fine powder. Gypsum is then added to the final burnt materials in order to regulate their setting action. The main distinction between the two materials vests in the vitrification process. The difference lies in the fact that lime, as mentioned before, is porous whereas compared to cement with its glass like structure is impervious and does have the ability to absorb and release moisture. The particles of cement are extremely small and so compact that once water has penetrated between the particles it impossible of being released and hence the material cannot breathe. An additional dilemma in the production of both lime and cement is the release of carbon dioxide. CO² is released from the burning lime stone as well as the fuel used to burn the stone. A higher ratio of lime stone is burnt in the manufacturing of lime compared to that of cement therefore leaving a greater carbon foot print however this balances out due to the ability of lime to re-absorb CO² gasses over its life time. Studies have proven the lime is able to re-absorb 60% of CO² that it omits during the manufacturing process over a one hundred year period. **(Allin, 2012)**

2.1.3) Types of Hempcrete:

After numerous testing and trials over the years four different types of hempcrete have been established namely, light weight, wall, floor and hemp plaster (which will be discussed in a preceding chapter entitled *Finishes*). The different uses of hempcrete are dictated by the type of structure and the elements of insulation which persist, the hempcrete can be suited to these conditions by combining the hemp hurds with varying the amount of binder. **(Allin, 2012)**

2.1.3.1) Light weight Hempcrete:

This type of hempcrete is principally used as an insulation material and therefore structure is of unimportance. The reason behind this is due to the fact that light weight hempcrete is usually only applied to areas where its primary function is to stay in place for example wall partitioning. Only 10% of the mixture consists of lime, this amount is sufficient enough to coat the hurds and bond them together resulting in a weak mass. It is not advisable to apply this type of hempcrete where it is required to act as a supporting structure and must only be used as an insulation material. In contrast to other insulation material light weight hempcrete will not compress and sag over time due to its breathable qualities. When applied into voids this form of hempcrete leaves no gaps and fills the void entirely therefore eliminating thermal bridging from occurring in addition to this it also has the advantage of being a fire retardant. Typical places where light weight hempcrete can be applied include; interior wall partitioning, roof spaces, behind weather proof facings of external walls and between floors to provide thermal and acoustic insulation. The required mixing ratio is as follows; 0.18m³ hemp, 0.4m³ water, 0.1m³ non hydrated limes, 0.2m³ lime and 0.05 m³ of cement. **(Allin, 2012)**

2.1.3.2) Wall Hempcrete:

This type of hempcrete is required to be able to withstand substantial amounts of forces due to wind and impact therefore additional structural rigidity is crucial. The manner in which this is achieved is by increasing the volume of lime in the mixture to 25% of the entire mixture's volume. The increase in volume causes the hemp particles to bond more solidly together in a more rigid way in addition to retaining the majority of the mixture's insulation qualities. Wall hempcrete is classified as non-load bearing masonry and is only sufficiently strong enough to supply additional rigidity to the timber framework against which it is cast and is unable of supporting timber roof trusses and floor joists. This type of hempcrete can only aid minimal timber frames from withstanding deformation caused through compression or damage caused by wind loads. In theory it is only possible for wall hempcrete to support a roof if a ladder like wall plate is used that evenly distributes the roof's weight. To achieve a satisfactory wall mix the following ratio should be used; 0.18m³ hemp, 0.6m³ water, 0.15m³ non-hydrated lime, 0.3m³ lime, 0.05m³ cement. **(Allin, 2012)**

2.1.3.3) Floor Hempcrete:

Floor hempcrete is mostly used as an insulation material beneath solid ground floor levels and therefore is required to have the ability of withstanding loads presented by the screed and floor finish above, the gravel beneath it as well as from under floor heating systems in some instances. Due to this an increase in the mixtures compressive strength is required and is achieved by increasing the amount of lime to 35% to that of its volume. The gravel beneath the floor hempcrete serves the purpose of ensuring that the mix is able to breathe however if the ground beneath the gravels is of a damp nature then the gravel is required to be ventilated. In order of obtaining the best results when mixing floor hempcrete the ratio applied should be: 0.18m³ of hemp, 0.6m³ of water, 20m³ of non-hydrated lime, 0.3m³ hydrated lime, 0.05m³ cement. (Allin, 2012)

2.2) Hemp Blocks and Bricks:

First and foremost a distinction needs to be made between hemp blocks and hemp bricks; hemp blocks are of a non- load bearing nature whereas hemp bricks are of a load bearing nature since they are of a smaller and denser nature when compared to hemp blocks. (Allin, 2012)

It has been established for many years now that it is far simpler to construct a wall out of bricks as opposed to casting a mould of the wall, this conclusion can now also be based on hempcrete. A hemp block is simply created by moulding hempcrete into a shape of a block (although it is possible to mould hempcrete into a variety of complex shapes). In contrast to clay or concrete blocks, hemp blocks can be fabricated to several times larger than that of concrete or clay and hence increases the rate of construction. (Allin, 2012)

Extreme caution must be taken whilst moulding hemp blocks as the material is much heavier and frail in its wet form; it is advisable to only handle the block once 70% of its moisture has evaporated. In some applications the setting time of the blocks can be between one and two months however this is dependent on the type of binder used. This situation would have proven to be detrimental if the completion of the building was urgent of nature however today there are a number of binders available which contain accelerators within them that speed up the setting time of the blocks.

During the drying period it is essential that the blocks do not adhere to one another and therefore spacers need to be set between the blocks. **(Allin, 2012)**

Some versions of the block contain pre-cut holes for services this however is rendered fruitless in some cases as it is difficult to align such holes during construction; it is far easier to drill and cut the holes when needed. These pre fabricated holes however do have the advantage of increasing the drying time of the blocks. Some blocks contain grooves and channels over the top and bottom facings in order to provide an interlocking bond with the mortar. The blocks are bonded together by a mortar consisting of a lime and sand mixture. Minimal joints can be produced by using the correct blocks and lime mixture and is basically achieved brushing the paste on to the blocks preventing thermal bridging from occurring. **(Allin, 2012)**

Hemp bricks on the other hand are produced by companies such as *Cannabric* in Spain and are much denser than the blocks. As mentioned before hemp bricks are of a load bearing nature and therefore the need for a timber framework is eliminated. The same techniques used in traditional brick construction are employed in hemp brick construction; arches over openings can even be created thus eliminating the use of lintels. **(Allin, 2012)**

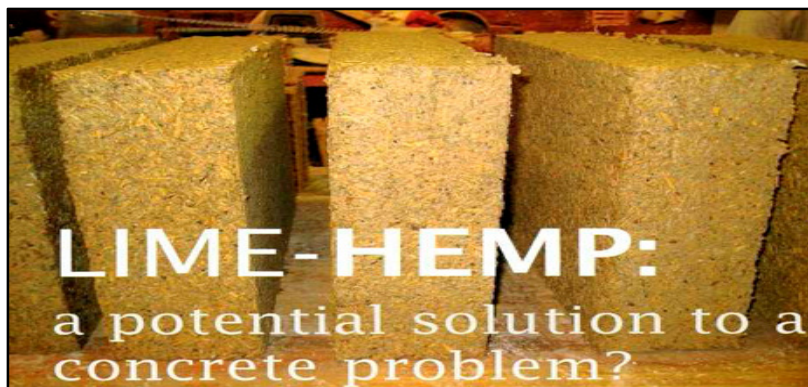


Figure 1 Hemp bricks. (www.organicaworld.com 2012)

2.3) Hemp Panels and Pre fabrication:

2.3.1) Panels:

Hempcrete in the form of standard cladding panels is currently being developed by *Cannabric* in Spain and its potential is on the increase. In this form, the hempcrete is required to be stronger and more durable in order to prevent damage during loading and transportation. In more delicate situations the panels are fabricated within a steel frame to ensure that it can handle the strain when lifted and placed in position. **(Allin, 2012)**

This type of construction was recently applied to a wine warehouse located in Northern London where the panels were cast into a timber frame and placed into position by the use of a crane. Further, the exterior of the building consisted of hempcrete filled cassettes which were bolted onto a steel frame and enclosed within steel sheeting. The owners of the building are now reaping the benefits of building with hempcrete as vast amounts of energy is being saved, the buildings requires absolutely no heating and cooling during warm and cold seasons respectively and saves approximately £40000 annually**(Allin, 2012)**

Hempcrete manufactures in France are currently developing hemp ceiling panels. During this manufacturing process the hemp hurds are processed in such a manner that they contain a certain percentage of fibre that contributes to the reinforcement in the hempcrete matrix. Due to this process a thickness of 50mm can be achieved for the panels. **(Allin, 2012)**

2.3.2) Pre-Fabrication:

In this context the word prefabrication refers to constructing sections of a building from the use of hempcrete panels, in a certain location and assembling them on site. An immediate advantage of this form of construction is the ability of the hempcrete to dry out in specifically controlled conditions in contrast to drying out on site where the prevailing weather conditions play a vital role. Once the panels are ready to be assembled they are placed by means of a crane, this leads to the second advantage of a reduced construction time. Examples of pre fabricated construction are retail out-

lets constructed in the UK and a house constructed in Abiosa, Switzerland. (Allin, 2012)

2.4) Plant, Tools, Equipment and Methods of Construction:

2.4.1) Plant etc:

Hemp construction is very much similar to conventional construction and requires no special or unusual types of equipment. Like most construction projects the use of scaffolding plays a major role and is used in the erection of timber frames when constructing with hempcrete. Experience over years of hemp construction now proves that it is more versatile to make use of light weight mobile scaffolding as opposed to the permanent alternative, reason being that permanent scaffolding tends to hinder access to certain areas at times. The use of cranes also plays a vital role in hemp construction in which it provides platforms to work off in addition to lifting and placing prefabricated panels. When mixing hempcrete it is essential to make use of a mixer with the largest drum capacity available as large quantities of hempcrete are required which are used up within a short period of time. Electric powered mixers are usually favoured over diesel power as they have the ability to be stopped between loads although when applying sprayed on hempcrete plaster an oil or diesel powered mixer is required due to the electric mixers inability to meet the require capacity. Other pieces of equipment required include a water tank and pump, a compressor for the concrete pump and a three phase power connection. (Allin, 2012)

There a mainly two categories of tools used in hemp construction, namely tools for moving and fixing shuttering and tools used in mixing and casting hempcrete in place. Tools required for shuttering include hammers, socket spanners and a drill (cordless preferably for efficiency). Large light weight shovels are best used for casting the hempcrete into cavities, the hempcrete mix is usually light and a large quantity can be scooped at one time. Owing to the fact that most types of hempcrete construction differ from one another it is best to make your own custom tool for compaction. The tool commonly used is in the form of a hammer with one pointed end in order to navigate awkward areas in the shuttering. Tools used in hemp plastering are the same as used for conventional plastering (Allin, 2012)

2.4.2) Mixing and Methods of Construction:

2.4.2.1) Mixing the Hempcrete:

According to (Allin, 2012) the mixing process of hempcrete is chiefly divided into four main steps:

Step 1: Dispense the necessary quantity of water into a stationary drum

Step 2: Add the measured amount of lime into the stationary drum to avoid excreting dust. Start the drum rotation and allow rotating for a few minutes until a lime/water paste is formed

Step 3: Add the hemp and leave to mix for approximately 3-4 minutes until all the hemp particles have fully been coated by the paste.

Step 4: Decant the mixture into the applicable container ready for construction i.e. a wheel barrow. To remove the hempcrete from the mixers drum before the next batch of the material is to be mixed simply add water into the drum and begin rotation.

2.4.2.2) Tamping Hempcrete:

In achieving a uniform consistency to the hempcrete it is vital to develop a type of system within the view points of the hemp lime ratio and the structural point of view. If the quantities of water and lime diverge from one another the visually effects and inconsistent behaviour of the mix shall become apparent once it has fully dried therefore it is highly essential that these quantities be controlled, constantly mixing the hempcrete with shovels before it is placed is an additional benefit in keeping the mixture consistent. It is highly important to level out the hempcrete after pouring it into the shutters before tamping it down, failure to execute this will result in compression of the top layer of the mixture only and not at the bottom. This will create pockets of untamped material which will disintegrate once the shutter boards are removed. Special attention must be given to areas where the hempcrete surrounds service pipes as a stronger hempcrete masses are required to be tamped down around these areas. (Allin, 2012)

2.4.2.3) Spraying Hempcrete:

Firstly before any spraying of hempcrete can occur the area needs to be prepped. This preparation process entails constructing frames around doors and windows to form the reveals and should be covered with a plastic to ensure that the hempcrete does not stick to the frames and result in damage upon removal. Wastage can also be avoided by laying a plastic along the wall on the ground in order to collect any fallen amounts of hempcrete. If any windows are installed within the frames it is advisable to cover them and mask them down in order to protect against damage and dirt. **(Allin, 2012)**

The spray on application of hempcrete indeed saves time when compared to the conventional tamping down process and over the recent years many machines have been developed however one such machine, developed by Lauret Goudet who currently resides in Brittany, stands out. In his invention the hemp and lime are firstly mixed together in their dry state. During application the mixture is blown through the machines pipes and water is added just as the hempcrete leaves the nozzle of the pipe, the amount of water added to the mixture is regulated by means of valves within the operator. The uniqueness of this type of machine lies in its ability to increase the rate of carbonation of the mixture due to the high pressure which propels the mixture through the system. Other machines have also been developed that propel the lime binder and hemp separately from one another and are produced in a variety of sizes, some requiring three phase power whilst others are able to run of 220-240 volt power however they cannot be used on regulated building sites. **(Allin, 2012)**

Spray on application and shuttering differ in the sense that with spraying the mixture is forced into the frame and against the shutter boards due to the direction of the force. Throughout the tamping process the mixture is pressed downwards resulting in the layers of the mixture bonding together, if this is overdone the shutter boards can be forced apart leading to a bulge in the wall. This scenario is highly unlikely to occur during the spray on application however due to the force of the pressurized mixture the insides, of the shutter boards needs to be lined with a polythene sheet to prevent the hempcrete from adhering to the shutters, the sheet is peeled off once the shutter boards are removed. Once the required thickness is achieved the surface is levelled off and raked flat. **(Allin, 2012)**

The use of hempcrete can also be applied to existing buildings in order to provide the building with extra insulation and, if the building is constructed out of masonry brick walls, an additional thermal mass. A plinth, usually in the form of a concrete aerated block, is a prerequisite when either spraying or casting hempcrete onto an existing surface as it provides support and acts as a foundation. The aerated blocks are installed above the foundation and a layer of damp proof course lined over it in order to prevent rising damp. In the case of a building constructed from a very hard material it is best to coat the surface with a lime and sand mixture prior to spraying on the hempcrete in order for it to stick onto the surface. In some instances the eaves and verges of the building's roof might need to be extended due an increased thickness. **(Allin, 2012)**

Casting hempcrete onto existing surfaces differs substantially as to when it is sprayed this is due to the force no longer being horizontal therefore ties are required in order to hold the hempcrete in place. These ties are usually in the form of timber pegs that are driven in between the mortar of the bricks or stone of the building, they can also be in the form of steel straps fixed with one end into the wall and with the other end pointing outward, prepared to be implanted into the hempcrete at the specified spacing **(Allin, 2012)**



Figure 2 Spray on application of hempcrete (Allin, 2012)

2.5) Application of Hempcrete:

Hempcrete can be applied to the following elements of a building; foundations, wall frames, window and door apertures, ground floor construction, floor and wall tiling,

suspended floors, partition walls, and even on roofs. Pictures of such application are included below. (Allin, 2012)

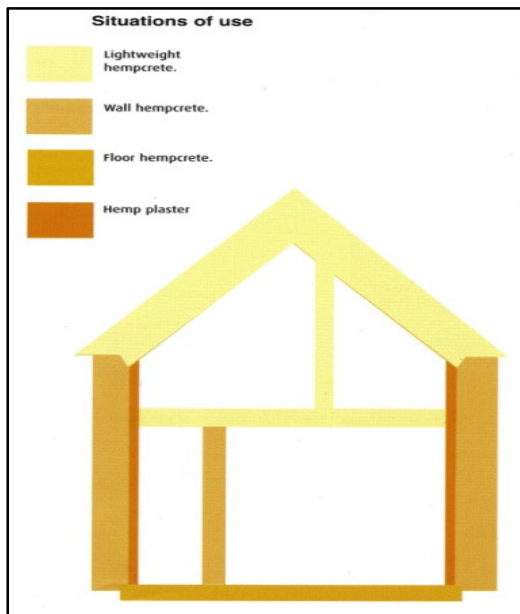


Figure 3 Typical uses of hempcrete on a house (Allin, 2012)



Figure 4 Hempcrete applied as a roof by making use of shutter boards. (Allin, 2012)

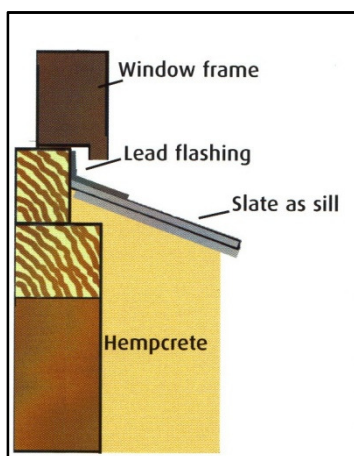


Figure 5 Window aperture applications. (Allin, 2012)

2.6) Summary and Conclusion:

There is no doubt that the content of this chapter proves that hempcrete and hemp bricks or blocks possess definite advantages over their traditionally used counterparts. (www.organicaworld.com 2012) defines the following advantages that a hemp brick holds over a traditional brick:

- Growing hemp to produce bricks improves the ground and does not require the use of and pesticides
- Hemp has a very low thermal conductivity , the brick holds excellent thermal properties against both hot and cold conditions
- The brick is fully recyclable and produces no toxic by products during manufacturing
- Brick is sound and fire resistant
- Minimal energy is used in the manufacturing if hemp bricks.

(www.hemphesis.com 2012) remarks that “hemp foundation walls are seven times as strong as concrete foundation walls, half as light and three times as elastic which means that they will bend but not break.”

2.7) Hypothesis:

The answer to the question proposed at the beginning of the chapter is as follows:

Hemp construction manifest in the form of hempcrete in which it could be applied as a spray on application or cast into shutters by making uses of simple tools, plant and equipment found on most conventional construction sites. It also could be in the form of bricks and blocks or pre fabricated panels. Like any trade in the building industry skilled labour will be required although semi skilled labour will adapt to the skills fairly quickly as it is much similar to convention methods such as in the case of applying shotcrete. The average labourer who has the skill and knowledge of how to batch and mix concrete will have no trouble in understanding how to mix hempcrete and the application thereof. From these statements the hypothesis can be accepted.

Chapter 3

What is the science behind hemp construction, its sustainability factors and Design Principles?

3.1 Introduction:

The construction of homes using hemp has been dubbed as “highly sustainable” by numerous institutions who have over recent years experimented with the material. This chapter explores the science behind this statement by taking into consideration previous research, the structure of a hemp plant as well as design alternatives and other elements such as the orientation of hemp homes in relation to the sun and the timber used in the construction process.

3.2) Practical tests undertaken in the past

3.2.1) Suffolk England 2001:

The most reliable and accurate tests undertaken with regard to hemp homes had taken place at Haverhill Suffolk in the U.K during 2001 and are commonly referred to in numerous sources of information. The project was conducted by the Suffolk housing organisation and entailed the construction of 16 homes constructed from traditional methods i.e. bricks and mortar and 2 constructed out of hemp. The study of these dwelling consisted of a detailed comparison of the following elements present in the two types of homes: acoustic, thermal, and permeable and durability properties, wastage factors, costs and environmental constraints. (www.eartheasy.com, 2012)

3.2.1.1) Acoustic Properties:

The standard requirement of the sound resistance for walls is that the average sound insulation should exceed 53db. In the study conducted at Haverhill both homes exceeded the standard with the hemp homes averaging at 57.5db and traditional methods averaging 63.5db respectively. From this test it is clear that the traditional building methods produce more satisfactory acoustic results as opposed to hemp building however in essence the fact still remains that a hemp building comfortably produced the standard required. Walls constructed from hempcrete also have the ability to absorb sound thus creating a more pleasant environment within the house as opposed to brick walls which reflect sound. (www.sufolkhousing.org, 2012)

3.2.1.2) Thermal Properties:

A detailed thermographic test was undertaken by the BRE by making use of an IR camera which took pictures of all elevations of the dwellings over a period of half an hour. The pictures taken are included on the next page. The concluding results were as follows; the internal temperatures of both the dwellings were recorded at 14°C more than that of the external temperature. Photos taken with the IR camera revealed that the hemp house was 4-6°C cooler than the masonry house. During tests conducted at night the internal temperatures of the different houses were of a similar nature. In conclusion the external walls of a hemp home were seen to withhold more heat compared to a traditional masonry house however weak spots appeared at the base of the foundation walls and along the upper part of the top floor below the eaves of the hemp homes. A solution in rectifying these weak spots is achieved by specifying better insulation during the design process. With regard to the consumption of electricity and gas between the two homes the independent results showed that the masonry home used more energy during the winter months (www.sufolkhousing.org, 2012)



Figure 6 Thermographic image of house constructed using masonry (Allin, 2012)



Figure 7 Thermographic image of hemp house constructed at Haverhill research project. Note the difference in colour between the masonry and hemp house (Allin, 2012)

3.2.1.3) Permeability:

The permeability level of the hemp homes was substantially favoured over the conventionally built homes. The reason behind this being that traditionally built houses make use of materials such as gypsum, plasters, bricks, mortars etc, all these materials retain moisture and are not vapour permeable whereas hemp on the other hand is naturally breathable and vapour retained within the material hastily escapes to the exterior. The possibility of condensation within the walls is thus eradicated and there-

fore warmth is achieved within the building. The hemp walls were further tested for water penetration and a full description of the test is discussed in detail in the next section (3.3). (www.sufolkhousing.org, 2012)

3.2.1.4) Strength and durability:

A visual assessment of the hemp homes subsequent to exposure to wind and ground movements proved that there were no indications of stress owing to the fossilisation process as discussed in the previous chapter. The sand and lime particles surrounding the hemp hurds aid against deterioration caused by weathering thus allowing the building to withstand for an indefinite period. Crushing tests of the wall mixes were also administered and the results showed that a mix absent of sand will deform as a load is applied to it hence the timber frame needed to structurally hold up the building. The mixture of hempcrete used on the floor level contained a larger amount of sand and therefore proved to be more firm, a 30mm thick sand/lime screed was applied to the floor slab and proved to support domestic loads when tested. An inspection of the hemp homes after a six month period revealed considerable cracking internally and externally largely as a result of drying out and natural settlement. This problem can however be dealt with and eliminated at the design stage. Following the testing it was clearly established that a dwelling constructed from hemp is equal in strength and stability when compared to convention masonry houses. (www.sufolkhousing.org, 2012)

3.2.1.5) Wastage:

A *SMART* waste analysis was undertaken and the results showed that with regard to excavated material the conventionally built houses produced 50% more wastage as compared to the hemp homes. Other forms of waste produced by the hemp homes resulted from packaging and off cuts; a minimal result of wastage was produced by the timber shutter boards. Wastage from the conventional buildings resulted in the form of brick and block off cuts as well as damaged goods in packaging. The final results concluded that the wastage in both types of construction are of a different nature and will in definite have an environmental impact. (www.sufolkhousing.org, 2012)

3.2.1.6) Assessment of the environmental impact:

It was during this assessment that the advantages of hemp construction over traditional construction were realised. These advantages were mainly found in the fact that hemp is a natural renewable material that has the ability to be produced in just four months. In addition to this the energy used to in the manufacturing processes of the three main ingredients, namely hemp hurds, lime and sand, are particularly lower than the embodied energy used in producing bricks and cement. Further advantages are found in the fact that; there is a reduction in the sub soil material excavated for foundations due to the fact the hempcrete superstructures are naturally flexible as well as a reduction in the amount of energy used during the demolition of the hemp dwelling once its useful life has expired and the materials being full recyclable subsequent to this. (www.sufolkhousing.org, 2012)

3.2.1.7) Comparison of the projects cost

The tender prices for each of the houses constructed from hemp amounted to £54000 while the conventional houses tendered at £34000 pounds. The costs were assessed in terms of the amount of quantities used as well as the time spent in constructing the houses. The key factor behind the higher cost of the hemp home is the fact that constructing with hemp at that time was an unknown trade and a considerable amount of time was spent in gaining experience whilst meticulously constructing the first home, the second home was completed in a faster period of time due to the gained knowledge of constructing the first house. At that specific point in time, the year 2001, the square meter price for constructing with hemp was priced at £526 whilst masonry construction was priced at a cheaper £478. In terms of South African currency the square meter prices would have roughly been R5786 and R5258 respectively (basing the Rand / Pound exchange rate at an average of R11 to £1 during 2001 according to www.x-rates.com,2012). (www.sufolkhousing.org, 2012)

3.3 Resistance:

3.3.1 Water Resistance:

The walls of buildings constructed out of hempcrete are most often of a solid nature therefore concern always arises of whether the buildings are resistant towards water absent the use of damp proof membranes or cavity walls. The BRE conducted a test to deal with this concern by mounting panels of hempcrete, sized 500mmx500mm, around a water spray device. The panels were finished on the exposed areas with a lime wash and lime render. The panels were then exposed to diverse rainfall patterns simulated by the water spraying device the first test was conducted around what was established as normal rainfall at 2- 24 hours. The results of this test showed that the water only penetrated through 20-40mm past the finished surface into the hempcrete. The second test was conducted over a 96 hour period which was equivalent to five years of continuous rain fall and the concluding results showed that the water only penetrated 50-70mm into the hempcrete beyond the finished level. It is safe to assume that continuous rainfall shall not persist and the walls have the ability to dry out after down pours. In the case of water penetrating above 20% of the moisture level problems will occur usually in the form of rotting of the hempcrete itself or of the timber frames mainly due to the fact that they are natural materials. The best manner in which to combat this problem is to apply a water resistant layer of lime render, this will aid against water penetration caused by wind and will only be effective if the correct sand to lime ratio is applied. The best approach in calculating this is to measure the volume of space between the sand molecules and is simply achieved by adding a quantity of water to dry sand. The volume of water measured at the end is equivalent to the amount of lime binder that is required in the render. The lime creates less space for water molecules to reside in the render. The use of denser materials such as NHL 5 or breathable paints also plays a vital role in aiding against water incursion and should be used in conjunction with the lime render to ensure ultimate protection. (Allin, 2012)

3.3.2) Fire Resistance:

Like with any other type of construction it is of vital importance that the materials used in hemp construction be fire resistant. Concern arises over the facts that most

natural materials are flammable and that constructing houses from materials which are 100% fire resistant are regarded as uncomfortable and cold to occupy. The best remedy to this concern is to ensure that the flames do not spread rapidly within the house along with containing toxic fumes released during the event of a fire. Research has shown that on an international level synthetic materials burn far more willingly compared to natural materials therefore if houses are furnished with carpets, wool, cotton, hemp etc the house is already at a lesser risk. The design and positioning of the hemp and timber frames are highly important in ensuring that the building is not unnecessarily dangerous in the event of fire as both hemp and timber are flammable. The hemp particles are however mixed and coated with lime which in its own properties is not combustible at normal domestic fire temperatures hence rendering the entire mix as safe. A number of tests have been conducted towards the fire resistance of hempcrete mixed (in a variety of mixes) in its wet form and the concluding results rendered the mixtures as *non-flammable* meaning that the mix smoulders or burns exclusive of flames. Similar tests were conducted against the material in its dried out form and the concluding results then established the material as *non-combustible*. The best way in which to achieve fire protection against the timber frames is to position and envelope the frame within the hempcrete mixture rendering it fireproof. **(Allin, 2012)**

Two separate incidents involving fire have occurred in Ireland and in both cases the only structural part of the building remaining were the walls constructed from hempcrete after the entire buildings had burnt out. In another incident resulting from an arson attack on a house constructed using natural materials and sustainable systems; the least damage was incurred by the walls plastered with hemp. **(Allin, 2012)**

Tests of fire resistance have been conducted by making use of a blow torch placed 8cm away from a block of hempcrete. The torch burnt until the canister fully de-canted which was timed at 7min and 30 seconds the results were of a visual nature and pictures of the tests after one, five and 7.5 minutes respectively are inserted below. (Allin, 2012)

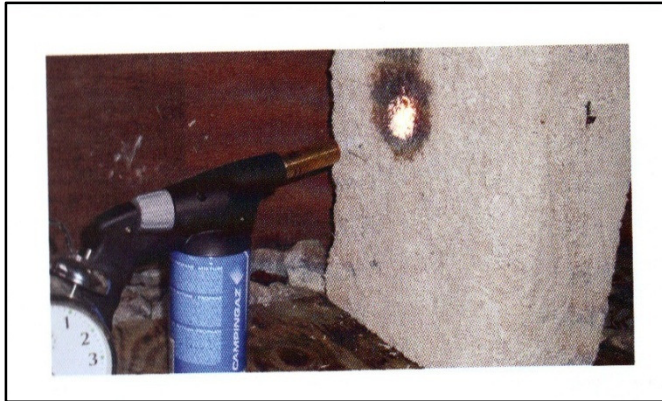


Figure 8 Resistance to fire after 1 minute (Allin, 2012)

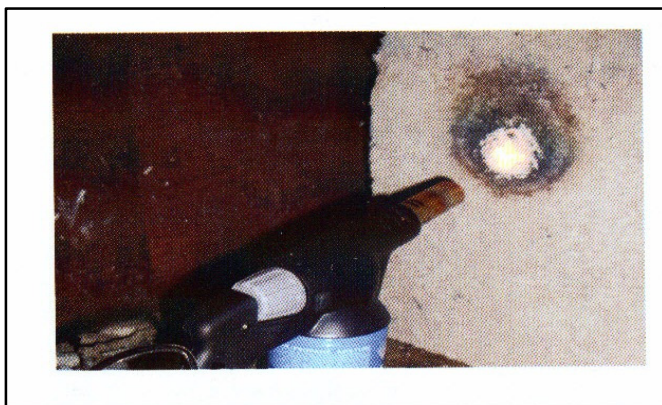


Figure 9 Resistance to fire after 5 minutes (Allin, 2012)



Figure 10 Resistance to fire after 7 minutes (Allin, 2012)

3.4) Inhabitable Experience:

3.4.1) Thermic Capacity and Inertia

This concept is defined as the combination between qualities relating to the thermic resistance (conductivity) and the capacity. The qualities of how a building reacts due to changes in temperature have been better understood due to the expansion of modern day knowledge by undertaking in depth investigations into how the building reacts towards internal and external temperature changes. To fully understand the results of this analysis references needs to be made to Figure 11 and 12 below

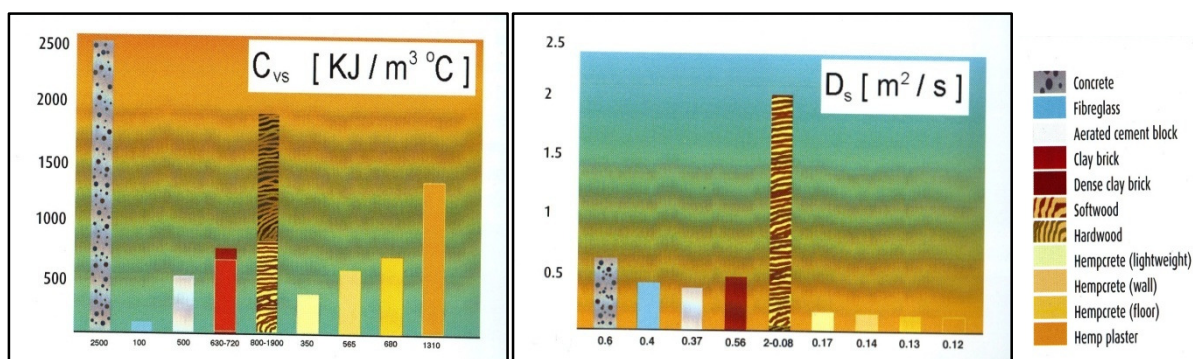


Figure 11: Capacity (Allin, 2012)

Figure 12: Inertia (Allin, 2012)

Figure 11 above reflects the thermic capacity of various types of commonly used construction material and it is clear that hempcrete produces the most approving results as a higher value represents a magnitude of heat which is regarded as uncomfortable. Figure 12 represents thermic inertia and it is clear that the inertia is affected by the mass the material. The concluding combined results prove that hempcrete, being a breathable light material, provides even temperatures when compared to other materials. The quality of inertia facilitates itself with the heat generated either naturally by the sun or by internal heating appliances and therefore this phenomenon must be taken into regard both in summer and winter. Calculating the thermic inertia of a building has proven to be a complex endeavour; essentially in order to produce a satisfactory result the material is required to contain a low conductivity and a high thermic capacity. These two aspects have proven difficult to merge. Two other key factors which play a role in influencing the thermic capacity and inertia are namely latent heat of moisture and humidity. Latent heat has been discovered as an additional leading aspect towards hempcrete's performance concerning energy use. The methodology behind this lies in the ability of the hemp hurds, due to its micro porous

nature, to encourage the passing of moisture through its structure. During this process the moisture vaporises and condenses. **(Allin, 2012)**

3.4.2) Comfort and Effusivity:

Effusivity is defined as the capability of certain material in discharging internally stored heat through its surface. Tests have shown that materials release heat from the surface once the air adjacent to it begins to cool. Heat stored within these materials can also result from the heat released by the human occupants of the building. The Effusivity of a building largely affects the comfort level that the occupants experience. The temperature that one feels inside a building is the average result of the air temperature and the temperatures radiated by the walls, thus the Effusivity plays a vital role. With regard to hempcrete neither the thermal comfort nor the conductivity reflects the level of comfort experienced. Calculating the Effusivity can simply be explained by stating that effs= the evolving speed of the superficially heat contained within certain substances. An indirect relationship exists between the elevation of the material and the cold temperatures it produces, in other words the higher the elevation of the material the lower the temperature hence discomfort is experience that is essentially due to the wall temperature being lower than the body temperature. This results in an exchange of a colder temperature between the wall and the body. At a lower elevation there is a weaker level of radiance and the body maintains thermic equilibrium without difficulty and the material is felt as subjectively "hot". The results of test conducted using hemp proved to be substantially satisfactory in this aspect. **(Allin, 2012)**

Hemp also has the ability to absorb other sources of energy such as sound. When sound waves travel through the hemp structure they are dampened, this is a result of the waves travelling into irregular voids within the structure this irregularity of the voids aid in diminishing the force of the waves, therefore good acoustic properties are apparent. **(Allin, 2012);**

3.5) Design:

3.5.1) Orientation and Energy Considerations:

When designing any type of building it is imperative to take the elements of wind, rain and the position of the sun into consideration. The main point that needs to be realised lies in making the best use of the materials in a specific environment in order to achieve a building that is simultaneously comfortable and economic to live in. Today many people seek to achieve this by making use of natural materials however it must be borne in mind that the majority of these materials are biodegradable and are susceptible to rot and decay. When using hempcrete in walls it is highly important to assist the materials' breathing ability by enhancing the amount of heat required in sustaining the correct level of humidity. Any moisture contained within the hempcrete needs to be withdrawn and removed by moving air. In cool climates this is achieved by allowing more sunlight to penetrate the building and locking the heat in, this ensures that the moisture will condense on the exterior. In warmer climates the insulating ability of the hempcrete aids in maintaining the correct level of humidity although ventilation is a prerequisite in controlling it. Never the less the orientation of the sun will always remain a key factor. Two methods of design orientation exist within this aspect; the first design entails facing the roof north (or south if building in the northern hemisphere) this will ensure that a larger area of glazing on the walls beneath the roof exists, allowing more light and heat in addition to the possibility of obtaining solar energy from the larger roof area. The second option is to expose the entire roof of the building to the sun in order to achieve a maximum effect. Building in this way will ensure that the materials will dry out hence preserving its durability. This method works particularly well in damp regions. **(Allin, 2012)**

The use of natural light and heat energy has a substantial effect on both the economic and health considerations of the occupants therefore it is decidedly significant to take these elements into account during the design stage. The position of the sun during all seasons must carefully be considered for example the angle of the sun is situated lower than in summer; this can beneficially be utilized by positioning windows facing the sun towards a wall which can store and radiate heat. Throughout summer and spring the sun's angle is much higher and can be exploited for natural light by making use of sky lights, in this way the heat will be stored and radiated by

the hempcrete used on the floor. In most instances hemp buildings require very little and sometimes even no additional heating however additional heating will be required in regions experiencing temperatures below 20°C. The best manner in which to provide the additional heat is by locating a central heat source, this will distribute the heat evenly throughout the house thus taking advantage of the excellent insulation properties found in hemp. (Allin, 2012)

3.5.2) Hard and Soft woods used in the frames:

3.5.2.1) Hard woods: Oak and Chest nut:

(A) Oak:

Oak has undoubtedly been established as one of the world's most strongest and durable species of timber used in the construction industry, a fact well proven by the existence of many houses built during medieval times that remain intact until today. The timbers within oak are exceptionally strong yet contain a certain degree of flexibility with the only disadvantage stemming from a longer growth period required compared to other species. The wood can easily be handled regardless of its hardness. On many occasions oak was used to construct frames while still being in its green form, this allowed the joints in the frames to tighten as the wood dried. Using the wood on this form will produce no ill effects when used with hemp due to the hemp enduring a minimum amount of compression. Oak can also be used in hemp flooring and panelling if seasoned and sawn in the correct manner. (Allin, 2012)

(B) Chestnut:

The nature of chestnut is similar to oak although the trees are not left to grow for as long as oak. The reasoning being that the wood is inclined to splitting as the tree grows taller. This type of wood is seldom used in hemp construction but mostly used as poles or shingles. (Allin, 2012)

3.5.2.1) Soft woods: Douglas fir, Scots pine, Larch and

Sitka Spruce:

(A) Douglas Fir:

Douglas fir (also known as Oregon pine) is a fine grained, durable and dense timber. This type of tree has the ability to grow than most other species therefore making it ideal for uprights and beams. The dimensional stability of Douglas fir makes it well suited to be used in conjunction with hemp and can be used while still green without the concern of shrinkage. **(Allin, 2012)**

(B) Scots Pine:

This type of wood primarily dominates in the northern hemisphere and is also known as Red Deal. Scots pine is not regarded as a reliable and durable material when exposed to external elements however it can still be used internally and is well suited to work with hemp owing to its strong fine grained timber qualities. **(Allin, 2012)**

(C) Larch:

There are three primary species of larch that occur specifically; European, Japanese and a fusion of the two. The fusion is the most renowned species used in construction as it has the ability to grow faster as well as the capability of resisting larch canker (a harmful defect) and wood worm. Larch is ideal for the used in hemp construction and has been regarded as being as good as oak. **(Allin, 2012)**

(D) Sitka Spruce:

Sitka Spruce is a type of timber that is most often grown for its low value however it is highly appropriate for the use in stud work where it is encased inside the hempcrete. This species consists of open grains that have the ability of absorbing lime thus strengthening the hempcrete. **(Allin, 2012)**

3.5.3) House Design Alternatives:

3.5.3.1) Timber Oak:

As mentioned before this type of design has been present since the middle ages and due to the strength of the materials and apposite construction methods many of these building still remain today. Traditionally the timber frame would have been filled with wattle and daub, straw and lime and in later year's bricks. Over recent years many modern buildings have been built using this concept of design however the frames are usually filled with toxic insulating materials. The use of hemp with this design is fitting and can be used in both renovation as well as new developments. In addition to the timber frames providing an attractive exterior and interior they also provide the possibilities of constructing cantilevers. In most cases the living areas do not occur on the ground level yet occur on the first floor level and sometimes extend into the roof therefore it is essential to use thin insulation material in order to save space. (Allin, 2012)

3.5.3.2) Post and Beam:

Post and beam construction makes use of larger and more extensive timber members and immediately creates the advantages of saving energy by not cutting timber members into smaller pieces as well as reducing the time taken to do so. The posts of many designs usually span over the entire width of the building in so creating a level point when spraying hempcrete as well as providing a surface upon which the shutter boards can be fixed. Once the exposed timbers have been treated or painted an aesthetically pleasing effect is created. This type of design is well suited for designs specifying the use of heavy external cladding boards. (Allin, 2012)

3.5.3.3) Stud Frames:

Over recent years this type of construction has become extremely popular. The frames used in this type of construction can either be erected piece by piece on site or alternatively assembled in offsite warehouse and joined on site. The proportions of timber members used in this type of design most often vary between 100mmx50mm thick and 150mmx75mm thick. When applied, the hempcrete fully encases the timber members thus strengthening the structure. Curved walls can easily be achieved

by using this method. Diagonal bracing is however required when using this design due to the fact that the dimensions of the elements are small in nature thus unable to create joints capable of withstanding lateral forces. Adding diagonal bracing increases a strength known as “racking strength”. Additional strength at the corners can be created by doubling-up the uprights or increasing the dimensions. (Allin, 2012)

3.5.3.4) Light weight Stud Wall frame:

This type of design has especially been produced for hemp construction by French architects Claude and Catherine Eichwald and consists of a combination of frames. This design encompasses a nominal use of timber with simple details around the doors and windows. The roof and floor are both supported by a strong centre column and beam frame upon which an exterior light weight spruce frame (usually sized 100x50mm) is attached. The need for internal shuttering can be replaced by making use of orient strand board which forms the interior wall surface according to this design. On the exterior side frames are fixed into the voids which are created for doors and windows. Once the hempcrete is applied to the frames rebates are inserted in order for the hempcrete to facilitate the door or window. Larch, oak or any other timber capable of withstanding external element should be used in the construction of the external frames. The internal frame can be constructed from round poles or even from previously used timber that is still in good condition which will in addition to recycling reduce energy use in cutting new timber. (Allin, 2012)

3.6) Summary and Conclusion:

The practical test undertaken by the Suffolk Housing Society in 2001 revealed many truths about the unknown innovation of hemp construction. The study comprised of comparison between hemp and masonry and the concluding results revealed that with regard to strength, acoustic properties, permeability and wastage no significant difference existed between the two however the hemp house performed relatively superior with regard to the thermal properties between the two although the conventional house proved to be more economic. The science of why hemp performs at a more enhanced level when compared to masonry with regard to thermal properties revealed that hemp hurds possess the ability to radiate heat back into the building at an increased rate therefore significantly influencing the Effusivity and comfort levels.

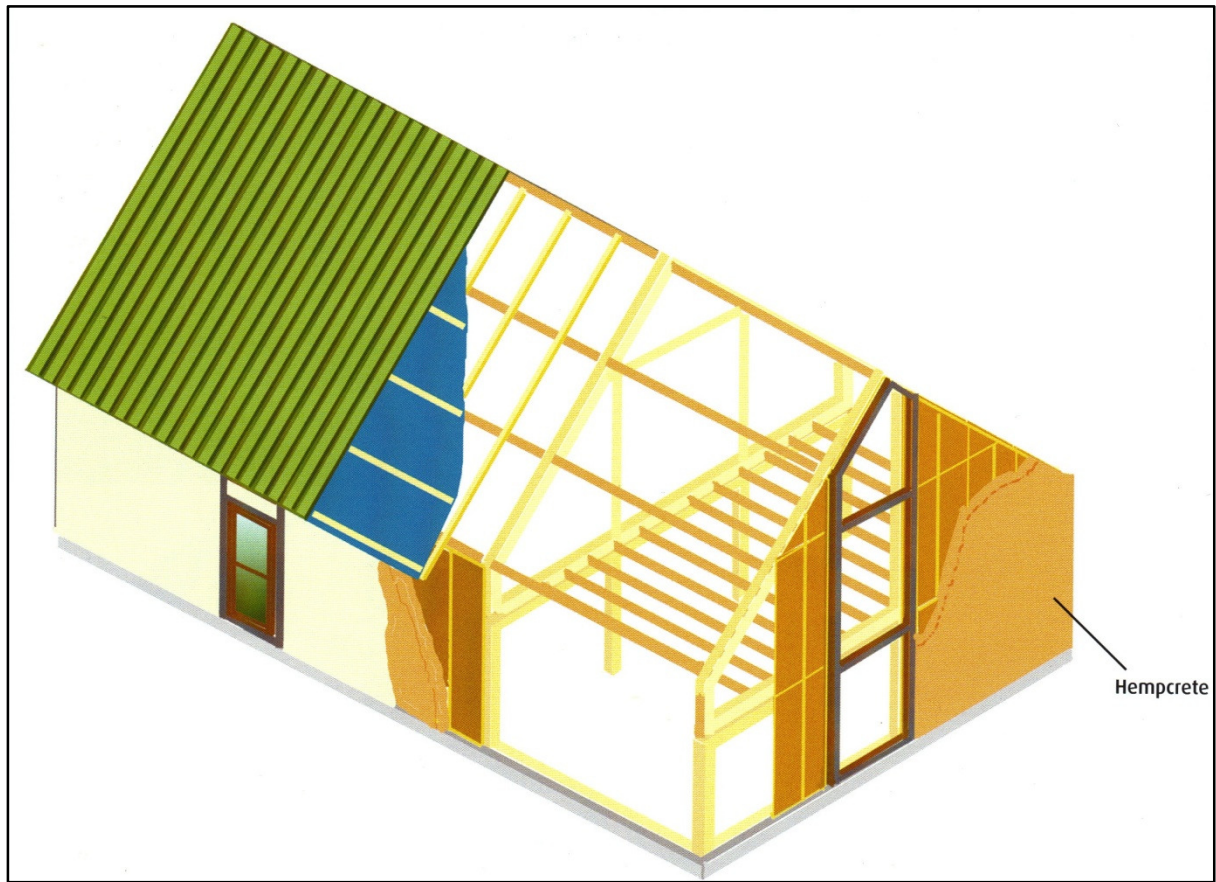
Both soft and hard woods are capable of supporting the structure of a hemp home in the form of frames. Many different design alternatives are available with the possibility of new designs arising each day. The perfect design suitable for hemp constructions was developed by combining past and future alternatives.

To conclude this chapter a safe establishment can be made in confirming that the use of hemp in construction will prove to be beneficial although expensive. The best manner in which to reinforce this statement is to refer to previously conducted tests. The test conducted at Haverhill Suffolk is the best study to refer to as it appears in numerous sources of information. The choice however, in countries where hemp is permitted, of whether to build using conventional materials or hemp solely vests in the desires and intentions of the owners. Hopefully in the future more countries will realise the benefits of hemp and the science of why it has been dubbed as sustainable.

3.7) Hypothesis:

In order to fully understand the concept of the science behind hemp construction one needs to analyse the elements present in this form of construction through extensive research. These elements comprise of thermal properties, permeability, strength and stability, acoustic properties as well as wastage factors. It is essential to study all these elements in detail. During this chapter it was discovered that hemp possesses excellent thermal properties which assist in retaining heat and as a result saves vast amounts of energy and money during winter months, this is primarily due to the scientific nature of the hemp hurds. In comparison with conventional methods of construction hemp construction was of a similar nature in terms of these elements however a diverse result was found in the costs associated between the two with hemp being the more expensive alternative. Scientific results explained in this chapter exposed the fact that a substance notoriously known for its release of a chemical narcotic by means of combustion can be made non combustible and totally fire proof. Comfort levels experienced in a house revolve around the science of heat radiation and absorption; both aspects proven to be advantageous with regard to hemp construction. This chapter revealed that making use of the sun as a natural energy source could prove to be highly beneficial. The science and logic present in medieval times was brought forth in today's modern era and used by French architects to produce the perfect design well associated with hemp construction. Keeping these facts

in mind the hypothesis can be accepted that hemp proves to be a sustainable building material.



**Figure 13 Light weight stud wall frame design developed by French architects.
(Allin, 2012)**

Chapter 4

What possible Finishes and other Products of hemp are available?

4.1) Introduction:

The versatility of hemp is immense and the material is not only restricted to a thermally efficient and breathable building material as so brought forth by this chapter. A variety of finishes and other products related to construction and sustainability can also be achieved. All these features shall comprehensively be discussed in this chapter.

4.2) Hemp Plaster:

4.2.1) Derivation of hemp plaster:

The concept of hemp plaster was established only since the creation of hempcrete. Ancient methods of plastering included the use of daub covering wattles or a mixture consisting of clay plaster reinforced with hay. The concept of hemp plaster hence stems from these methods. The proportions of the mix used in hemp plaster are established along the grounds of its application. Hemp plaster can be applied either by the use of air spray guns or by hand. Some applications merely require the use of lime and hemp whilst buildings in harsher conditions may require ground lime stones and sand in the mix either to assist in retaining the moisture during setting or to supply additional weight to the plaster in order to be effectively be used with a spray gun. The different variations of mixtures used in hemp plaster must be taken into consideration as the performance and appearance of the finished plaster is affected. Many houses finished off with internal hemp plaster have reported improved comfort conditions. Various experiments using hemp plaster are now being undertaken by self-builders resulting in the spread of its benefits. (Allin, 2012)

4.2.2) Mixing:

When hemp is desired to be used as plaster it is best to use hemp hurds that have been sieved and have dimensions between 1 and 10mm in length. Using finer hemp particles in the mix will provide an ease of application in addition to a smooth surface. In order for the hemp plaster mix to be applied more easily and adhere to the wall a higher degree of plastic consistency is required and is achieved by adding a higher concentration of hydrated lime to the mix. Adherence of the plaster to the wall is ensured by a higher concentration of ammonia in the lime. Sand may also be added to the mix to provide strength to the plaster and prevent damage caused by future battery. Accelerators in the form of pozzolans can also be added to aid in decreasing the setting time (**Allin, 2012**)

4.2.2.1) Proportions:

According to (**Allin, 2012**), three types of hemp plaster primarily exist namely wall plaster art can, wall plaster containing gypsum and floor mix used as screed known as alliance four. When batching for large projects its best to mix the ingredients continuously with best results achieved using pan or trough mixers. The quantities combined to produce satisfactory mixes are as follow as stated by (**Allin, 2012**)

A) Wall Plaster: “Art Can” mix:

Hemp: 0.2m³

Water: 0.06m³

Red Brick Dust: 0.03m³

Lime: 0.17m³

B) Wall Plaster containing gypsum:

Hemp: 0.18m³

Water: 0.06m³

Ammonia 3.5: 0.03m³

Lime: 0.02m³

Gypsum: 0.01m³

Fine sand: 0.01m³

C) Floor Mix Alliance Four:

Hemp: 0.2m³

Water: 0.06m³

Gypsum: 0.04m³

Lime: 0.04m

Pumice: 0.06m³

4.2.3 Methods of application:

As mentioned in 4.1.1 hemp plaster can be applied either by hand or spray on application.

4.2.3.1) Application by hand:

Before the plastering process can commence, correct preparation must be met. This process entails the protection of surrounding surfaces that do not require plaster. Timber elements of the building such as window frames and doors should especially be protected as the lime contained in hemp plaster has the ability to stain such surfaces. Wall areas around ceilings and cornices should also be protected by the use of masking tape as plaster applied unintentionally to the areas could prove challenging to clean. The consistence of the plaster is the most significant aspect as it is dependent on the atmospheric conditions, the surface to receive the plaster as well as the type of finish desired. A *one type "standard mix suits all"* type of plaster does not apply in this situation. The components of the mix should not be left in the mixer for too long as it produces a sponge like plaster due to the excess amount of air once applied. The mixture may seem to have a creamier consistency if left for too long and may appear to be suitable however it is not and a weak flimsy plaster will be created, the point is to produce a well combined mixture that will last. Hemp plaster does not bond to dry surfaces therefore the surface requiring plaster needs to be meticulously assessed for its water quantity as well as for the moisture it will absorb

once plastered. It is advisable to test a small area for its absorption before beginning to plaster, test by wetting a small area first then apply the plaster and if the wall is highly absorptive continue to do so in sections. On the other hand if a section tested is fairly absorptive then a large area can be moisturized and plastered. This type of plastering is dictated by personal preference and even professional plasterers find hemp plastering to be challenging as hemp plaster is not as supple as the cement sand plaster that they have become accustomed to. (Allin, 2012)

The physical process of applying hemp plaster by hand can be summarized into 7 steps according to (Allin, 2012)

Step 1) Prepare the surface to receive the plaster by removing loose rubble and levelling off

Step 2) Make sure the hemp plaster is mixed according to specification

Step 3) Apply the hemp plaster to the wall by making use of trowels etc

Step 4) Smooth out the freshly plastered surface and fill in gaps

Step 5) Level out the surface with float and bring the fat of the lime to the fore

Step 6) Allow hemp plaster to set over night

Step 7) Polish the surface of the plaster off the next day to embed the hemp fibres into the lime and ensure that the surface is smooth.

4.2.3.2) Application by Spraying:

It is highly important to take note that spraying hemp plaster is dangerous due to the hazardous lime particles that will cause damage to eyes when coming into contact therefore its vitally essential to wear all protective clothing whilst spraying. The spraying gun consists of a hopper and chamber through which the compressed air enters and comes with a variety of plates of varying hole sizes through which the hemp plaster leaves the gun. Large holes provide a rougher surface texture however allow for more plaster to be sprayed whilst smaller holes in the nozzles provide a smooth surface usually used as a finishing coat. Newer models also allow for small gravel to be sprayed. The spraying process is very much similar to spraying hemp-concrete as discussed in **Chapter 2** section **2.4.2.3**. (Allin, 2012)

4.2.4) Application in Renovation:

The re-plastering of any renovation project has always been a complicated process due to the nature of the surface requiring plaster or the process required in achieving the desired thickness by applying it in many layers. Hemp plaster has proven to be one of the best options when renovating as it has the ability of being applied to any thickness required to cover uneven area on the existing surface. Once again the separation of the hemp hurds into finer particles have proven to be at an advantage as the smooth plaster it produces is highly beneficial and more suitable for renovation work when compared to other alternatives. Numerous people attempting their own renovations have found great pleasure in working with hemp plaster. Many reports have stated that a significant difference has been felt with regard to the heating of a room between the old conventional plaster and the hemp plaster with the hemp plaster proving to be beneficial. (Allin, 2012)

4.2.5: Application in New Developments:

During today's modern era many people feel the discomfort of the "boxed up" feeling they experience in their newly built homes, this is primarily due to the flat surfaces portrayed by the walls. In this instance applying hemp plaster to the walls assists in softening up the lines and adding texture to the flat surfaces. The primary objective of applying hemp plaster in this case is to create a visual effect and alter the way in which light is reflected of the walls as opposed to exploiting the insulation properties of the hemp hurds. Whether making use of natural sunlight or candle light, a significant variance will be seen in the way in which light is reflected against a surface plastered with hemp. Roughly plastered hemp surfaces will appear to be softened under lighting where as a certain aspect of interest will be added to a flat and smooth surface. (Allin, 2012)

4.2.6) External Application:

The external application of hemp plaster is rarely undertaken nevertheless there are certain instances when its properties are perfectly suitable such as in the construction of houses using straw bale. On average these houses consist of an expanded steel mesh covering that enables the adherence of a traditionally used plaster. The need for such mesh is eliminated if hemp plastering is required as it is a light weight

material that can bond to the straw bales without any difficulty. The exterior of such building can be made to appear more realistic and suitable if the hemp plaster is coated with numerous layers of lime wash. In the case of plastering against a clay brick or block surface it is best to make use of the wall mix **(4.1.2.1, B)** which can be either sprayed or cast into place. Subsequent to the application of the hemp plaster the wall will be able to act as a thermal mass. **(Allin, 2012)**



Figure 14: Shows the different types of textures available from hemp plaster

1. Rough hemp plaster with lime wash
2. Rubbed finish
3. Rough unfinished
4. Sprayed finished with wood float
5. Smooth finish with lime wash

. **(Allin, 2012)**

4.3) Other Types of Finishes:

4.3.1) Hempcrete Cast Walls:

A very attractive finish is achievable through a cast hempcrete wall on its own; this is due to the tannin in the hemp being brought forth through the lime. This type of finish has been said to be more attractive than the finish created by the application of hemp plaster. The manner in which the hempcrete was cast initially will dictate the practicality of the outcome when such finish is desired. The degree of wear and tear against the walls is dependent on the manner in which the hempcrete is compressed within the shuttering during construction. A lime paste mixed according to the same ratios of the hempcrete mix can also be applied to the bare hempcrete wall and is applied as lime wash. Applying this paste will ensure that all hollow spaces are filled in along with increasing the bonding the surface particles. **(Allin, 2012)**

4.3.2) Rubbed:

This type of finish is achieved by rubbing the freshly hemp plastered surface with ones fingers covered with a glove. This method will also ensure that the hemp hurds are completely embedded within the lime. With walls containing curved lines or sharp corners, this type of finish is ideal for emphasising these features. If this type of finish is applied correctly the end result will be a surface that requires no paint. **(Allin, 2012)**

4.3.3) Trowel Work:

Applying the hemp plaster with a trowel and partly smoothing it out provides yet another attractive finish. If this type of finish is desired it is recommended that a lime paste be applied as it aids in smoothing out unworkable sections of the wall. **(Allin, 2012)**

4.3.4) Tadelakt:

This class of finish originated in Morocco and refers to a waterproof type finish usually applied to baths basins etc that are coated in a coloured lime plaster which is smoothed out and sealed with soft soap. A Tadelakt type finish is suitable with the

use of hempcrete as it is a highly malleable material that can be shaped into baths, shower cubicles and basins with a certain amount of skill. **(Allin, 2012)**

4.3.5) Paints:

Paints manufactured from natural limes are starting to make a re-appearance in today's modern era with its popularity increasing vastly. These types of paints are well suited for use with hempcrete as they contain lime, the two elements then working in conjunction with regard to moisture and humidity influences. A definite distinction exists between conventional modern day petro-chemical paints and older natural paints with the main difference found in the drying process. Petro-chemical paints continue to dry out through evaporation of the spirit solvents contained within it, this process normally continues until the paint cracks. Natural paints on the other hand, particularly lime based paints, do not dry out as they lock in a certain amount of moisture which keeps the paint flexible additionally assisting the paint in adhering to the surface. As discussed before walls consisting of hemp reflect light in a different way, this effect can be enhanced by making use of natural lime paints as the minute particles of the lime are well suited for the textured hemp surface. Other suitable mixture of that are compatible with hempcrete include the addition casein and quark, these products also aid in creating an aesthetically pleasing effect. **(Allin, 2012)**

4.3.6) Cloth and Paper:

A raw hempcrete wall can be finished off by making simple use of cloth or paper. Like an artist's canvas the fabric can be stretched over the hempcrete walls and painted as desired however it is essential that the material be ironed and free from creases. The only matter which requires a fragment of concern lies in the method of joining pieces of the materials together as well as the method of fixing the material against the wall. This can become a cumbersome task if the wall has a certain aspect of character to it. The most versatile way of fixing the cloth onto the wall is by making use of pins which can be either left exposed or hidden depending on the desired result. Any type of material can be used i.e. from fine linen to rough canvas. Using a cloth covered finish has the advantage of reducing the amount of water used in construction which in turn reduces the drying out time, a beneficial factor in wet climates. Wall paper can also be used to finish off the hempcrete wall if it is perfectly flat although it is advisable to first cover the surface with a layer of lining paper to en-

sure a level surface. The exposed texture of the hempcrete can also be achieved in addition to having an aspect of colour; this can simply be achieved by making use of tissue paper which can be applied in large sheets or in patches of multiple colours to create a psychedelic effect. (Allin, 2012)

4.4) Other Products Available:

4.4.1) Hemp Boards:

Traditionally manufactured chip or particle boards consist of timber chips from trees that have been cut down from valuable forests in a highly unsustainable and polluting manner. The glue that binds these chips together is yet another environmentally unfriendly factor due to its formaldehyde levels, many green contractors and architects are opting for the use of natural glues found in the form of eucalyptus gum and potato starch. The use of hemp hurds and natural glues are now becoming a better option as they are natural and renewable at rapidly rate. The hemp hurds need to be ground to a finer particle in order to ensure uniformity when such boards are manufactured. The main downfall of producing hemp board is found in its high prices and it is best to produce such boards only when there is a substantial surplus of hurds that cannot be sold, only then will hemp boards be able to compete with timber chip boards. China is currently the leading supplier of hemp boards. (Allin, 2012)

4.4.2) Hemp carpets and underlay:

The use of carpets has dramatically declined over recent years as more and more people have become susceptible to allergies and have rather opted for tiles which aid in increase the discomfort caused by cold. Hemp can be used to produce carpets and underlays which will contribute to ensuring a warmer and hence more sustainable home. Once again the downfall lies in the cost of the hemp fibres as completion fibres such as jute are much cheaper. Small scale production of hemp carpets has started in India with such carpets used in South Africa first hemp home. France is however the leading country in producing hemp fibres used in carpet underlay. (Allin, 2012)

4.5) Summary and Conclusion:

It was discovered in this chapter that hemp plaster is a derivation of hempcrete and was influenced by ancient construction methods which consists of three primary types of mixes. There are principally two ways in which hemp plaster can be applied namely by hand or by spraying. Hemp plaster can be used in new building developments as well as in the renovation of old buildings; although it is not suited for external used, the task can be achieved. At this point many other types of finishes can be achieved aside from hemp plaster with new innovations being realised every day. Multiple products used in construction are now stemming from hemp however they are not proving to be economically complete

At the end of this chapter it can be concluded that the uses of hemp in the construction industry are starting to make a substantial impression although many nations still abolish the use of hemp and are missing out on the benefits of this fibrous and versatile plant. More and more innovations of the plant in the construction industry are being discovered every day.

4.6) Hypothesis:

The answer to the question entitling this chapter is as follow: there are numerous finishes available with regard to hemp which include hemp plaster, the texture of a raw hemp wall itself, Tadelakt surfaces over hempcrete, trowel finishes and rubbed finishes but to name a few. All these finishes available have an influence in the way in which natural or artificial light is reflected within the walls of a building. This feature is largely due to the components of the hemp and lime mixture and can provide aesthetically pleasing effects as well as an enhanced usage of lighting in a room. There are also other products available stemming from hemp in the form of carpets and boards both relating to the construction industry as well as to sustainability however the small scale production of these products result in higher prices when compared to competing products. From this the hypothesis can be accepted by establishing that there are numerous types of finishes available in addition to newer innovative products consisting of hemp, all of which assisting to create a sustainable way of future living.

Chapter 5

Is there a relationship between the economic factors of hemp construction and the South African legislation regarding Cannabis in addition to the general perception of hemp?

5.1 Introduction:

The contents of this chapter shall address the crux of the matter concerned within this research report i.e. is hemp construction in South Africa too expensive at this point in time due to legislative restrictions enforced by government. This chapter will discuss the hemp industry currently present in South Africa, perceptions of hemp from the view points of the public (particularly the youth) and contractors, as well as South Africa's most sustainable home constructed out from hemp.

5.2) The hemp industry in South Africa:

Over centuries hemp has been grown in South Africa mainly for its medicinal benefits. In 1903 the South African legislation regarded the crop as illegal when the prohibition of marijuana was passed worldwide. Since 2009 the government and private sector have been exploring various alternatives in trying to amend the current legislation and permit the growing of hemp on a commercial level. Currently hemp is only permitted to be grown for scientific and research purposes in South Africa. There are numerous areas in South Africa where hemp has been planted for research with the very first plantation-developed by the **A.R.C**- occurring in the North West Province near Rustenberg. Other institutes developed by the **A.R.C** can be found in Eastern and Western Cape, Kwa Zulu Natal, Gauteng and Limpopo. A study undertaken in 2009 revealed that France was the largest producer of hemp whilst no African countries produces hemp at all mainly due to the legislative restrictions.

(www.daff.gov.za, 2012)

5.2.1: Hemp market in South Africa:

An adequate amount of hemp is not produced in South Africa solely due to the fact that the crop is illegal; despite this a market does exist for the product. Hemp is mostly imported into the country mainly for textile uses. Hemp based products such as soaps and clothing are manufactured in South Africa however the raw material is imported which automatically leads to an increase in the price of such items. The graph depicted below illustrates the importing and exporting of hemp into and out of South Africa from 2000 to 2009.

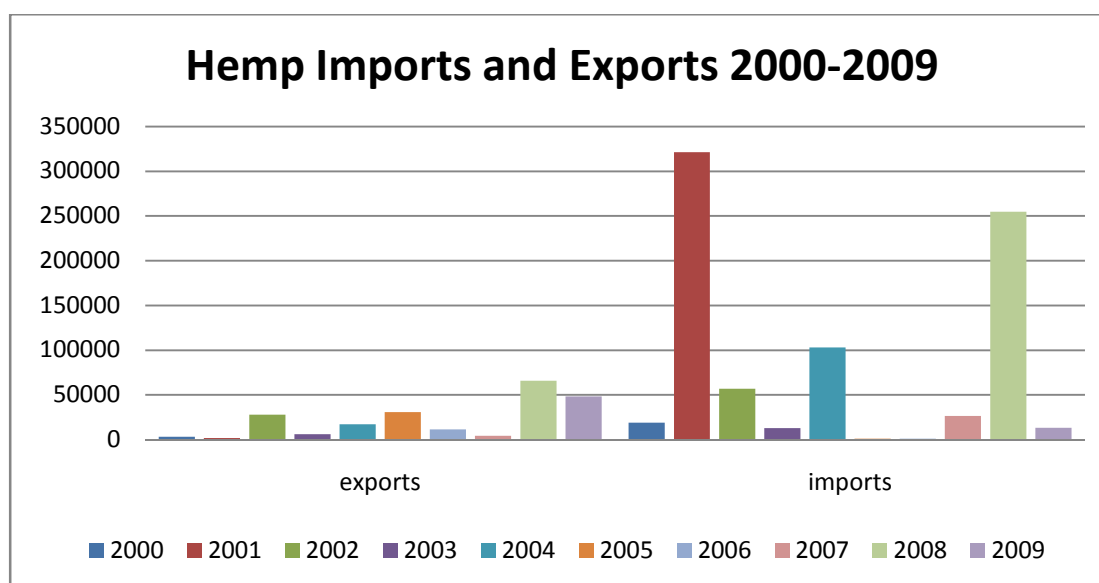


Figure 15: Hemp imports and exports in S.A (www.daff.gov.za, 2012)

It is clear from this graph that South Africa is a large net importer of hemp. The contents of hemp mainly imported are seeds and fibres. The products manufactured from hemp are in large demand in South Africa and are imported from countries that legally cultivate the crop, the raw material is then processed and some of the products then exported. The graph also illustrates that the hemp export values over the ten year period remained below R50000 with the exception occurring in 2008 when hemp export prices soared. It was established during this research period that value of imports always exceeded the value of exports. The exporting of hemp during the 2008 period mostly occurred between South Africa and other African countries, an approximate volume of 1377 kilograms of hemp products were exported during that period. Other than exporting hemp products to African countries South Africa also supplies Europe with a vast amount of hemp products, this is mainly due to the preferential tariff agreements between the two resulting in exports to Europe being

cheaper as opposed to exporting to other countries. The main countries supplying South Africa with hemp include America, Asia and Europe primarily due to the fact that the cultivation of hemp is legal in these countries. Hemp required for the use in building material is mainly imported from Europe. (www.daff.gov.za, 2012)

5.2.2) Challenges against hemp in South Africa:

The cultivation of hemp for research purposes in South Africa is only permitted upon the grounds of the terms and conditions granted in **Section 22A (9) (a) (i) of the Medicines and Related Substances Act 101 of 1965**. (www.daff.gov.za, 2012)

According to (www.daff.gov.za, 2012) the abolishment of hemp cultivation in South Africa is primarily due to the following legislations:

- ❌ **The Drug and Drug Trafficking Act. 140 of 1992.** In this Act no distinction is made between hemp and narcotic marijuana. The South African Police service enforces this Act.
- ❌ **Medicines and Related Substances Act 101 of 1965. Section 22A (9) (a) (i)** of this act states that a license or permit must be obtained from the Department of Health. Possession and cultivation can only be for research purposes.
- ❌ **The Environmental and Conservation Act. 73 of 1989.** This Act considers hemp plants as a weed or invasive alien plant species. The Department of Environmental Affairs and Tourism enforces this Act.

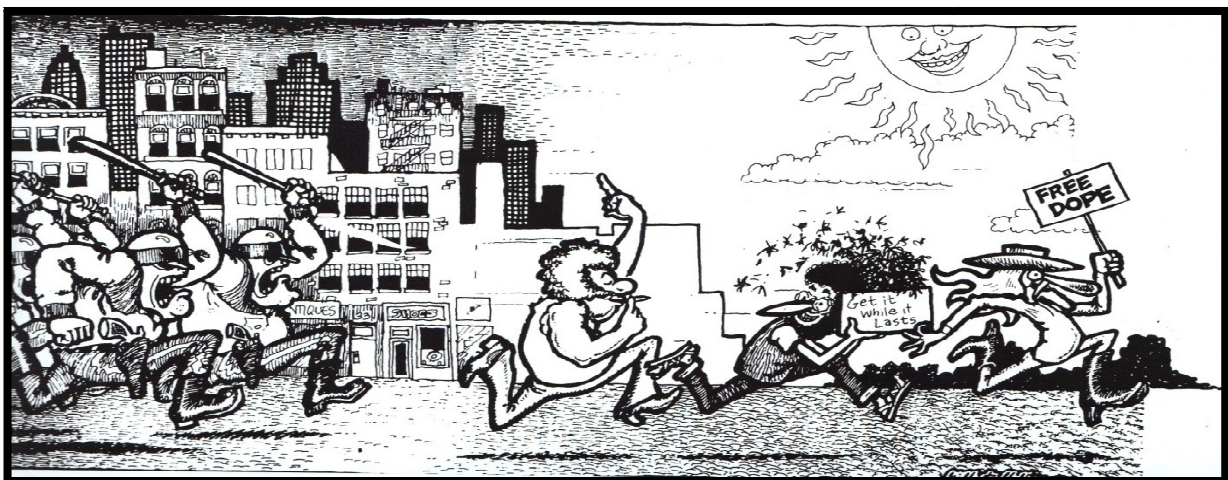


Figure 16 “Fabulous Furry Freak Brothers” by Gilbert Shelton (Allin, 2012)

5.3) Perceptions of hemp in South Africa:

The research in justifying the general perceptions of hemp and cannabis involved the answering of questionnaires by the public and built environment professionals. The results of both questionnaires are discussed hereunder; the headings of the following sub-sections represent the questions asked.

5.3.1) Questionnaire one; “Do you think that Cannabis should be legalized? Note that this may lead to a greater tolerance in Hemp which could benefit all of us in some or other way.”

This question was specifically designed for the public particularly the youth of this country as their opinions of today shall have a vast influence in the future. The best manner in which to obtain such information was found in posting the question on the largest social networking site, Facebook, as this seemed to be the most efficient and less time consuming manner. A total of 335 people were presented with the question. The results are graphically represented below in **Figure 17**

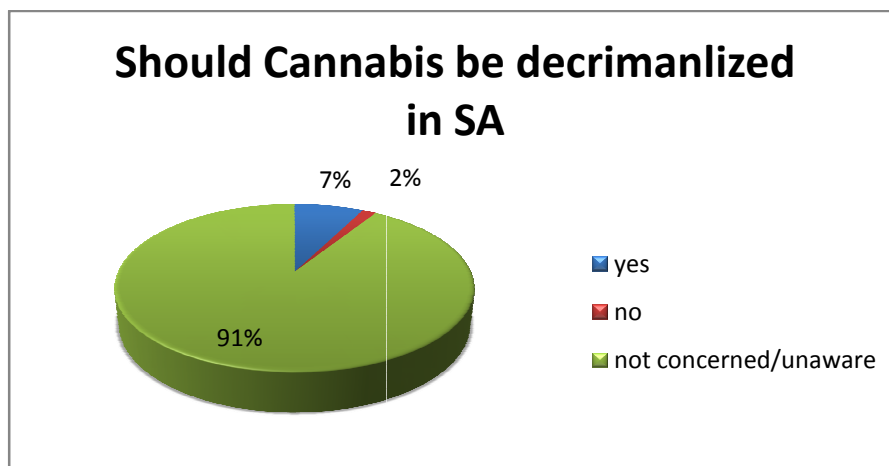


Figure 17: Results obtained from Facebook questionnaire.

The results of the questionnaire clearly prove that the majority of people today are unaware of the beneficial properties of hemp whilst a smaller minority are. People are more likely to respond to questions or statements regarding more mainstream issues such as fluctuations in the price of fuel or privatisation of the Gauteng roads. The concluding results of this questionnaire hence reveal that a versatile crop that

had thrived in the mainstream over a hundred years ago has no recognition today except for narcotic recreational use. People are unaware of the other uses of hemp such as the manufacturing of clothing and bio mass fuels, if hemp could be cultivated locally in South Africa with the implementation of manufacturing these or more products a drastic decrease in prices could be possible.

5.3.2) Questionnaire two: “Are you, as a construction professional, aware of the use of Hemp (Cannabis) as a sustainable building material?”

This question specifically targeted the major contractors in the Pretoria area as well as a few quantity surveyors. A total of thirteen professionals were asked the question and the findings are represented below in **Figure 18**

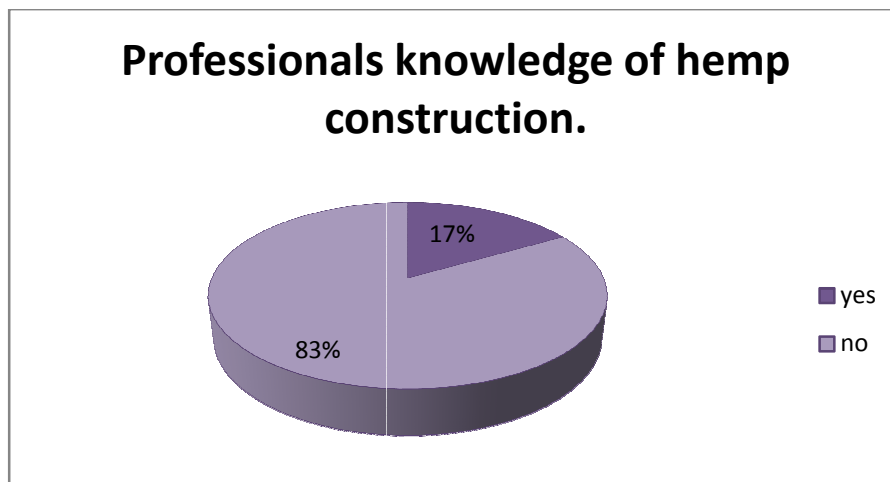


Figure 18: Results obtained from questionnaire presented to professionals and contractors

The results of this questionnaire prove without a doubt that sustainable building with hemp is yet an unknown venture in South Africa. Many contractors and other individuals in the industry lack the knowledge of how sustainable and easy it would be to construct using this material in addition to providing economical benefits if grown locally at a commercial level. Unfortunately many of the professionals make no distinction between hemp and narcotic marijuana thus leaving the material open to humorous stereotypical mockery. The concept of hemp construction needs to be expanded vastly in order to have an impact in the sustainable green building industry of this

country and the best approach in achieving this would be to educate contractors and professionals of, any level, about the benefits and pitfalls of hemp construction.

5.4) South Africa's first Hemp Home; the most sustainable home in the Country:

5.4.1) The Concept:

South Africa's first hemp constructed home is brainchild of Tony Budden, Duncan Parker and architect Erwin van der Weerd. The concept behind this building was to create an eco friendly and highly sustainable home using natural and organic materials. The house is situated in Noordhoek Cape Town and over looks Noordhoeks valley and Longbeach area. The objective of the interior of the building was to create a modern, energy efficient, warm and organic internal environment by making use of hemp and other natural material. (www.hemporium.com, 2012)

The architect, (**van der Weerd**), explains the concept in his following words "we have to make sure that the impact on nature is reduced. We design houses and spaces with a natural air flow to reduce heat absorption, so the need for air conditioning is reduced in summer." (www.hemporium.com, 2012)

5.4.2) Features of the building:

5.4.2.1) Hemp Materials used:

Owing to the fact that the main focus of this project was construction using hemp, the majority of materials and finishes in the house consisted of hemp products. These products include: hempcrete in the walls, hemp particle boards present in the cupboards and wall cladding, hemp carpets on the floors, hemp fabric in the curtains and couches, bed linen and lighting, hemp insulation under the floors and the use of hemp oil as a protective coating for all timber surfaces. (www.hemporium.com, 2012)

5.4.2.2) Fenestration:

The house also features double glazed windows that complement the insulation properties found in hemp, the windows prevent heat from seeping out due to their double glazing gas filled seal. In addition to this there are also windows that have the

ability to automatically open and close under the control of a thermostat; this ensures that the house has the ability to cool itself without the use of air conditioning. Features like these are often expensive however it must be borne in mind that the expense can be recovered due to saving in the consumption of energy in the long run. (www.hemporium.com, 2012)

5.4.2.3) Kitchen and Bathrooms:

The elements of the kitchen were constructed from recycled second life stone tops and recycled Oregon and pine in the cabinets. Once again in the bathrooms second life stone tops were used on top of bamboo cabinets, bamboo was specifically chosen due to its properties of strength, sustainability and water resistance as well as for an aesthetic appeal. (www.hemporium.com, 2012)

5.4.2.4) Flooring:

The flooring of the house consisted of cork mainly due to its attributes of anti allergic properties, softness and durability in addition to this the cork is produced only from the bark of the tree therefore causing no damage to the tree, allowing the bark to re-grow and proving to be yet another sustainable feature of the house.

(www.hemporium.com, 2012)

5.4.2.4) Paints:

B- Earths supplied all external and internal paints. Paint manufactured by this company was particularly specified due to its durability and water resistance properties as well as the low release of toxic metals and volatile organic compounds (VOC) during and after application of the paint. The paint is however classified as a “zero VOC” paint as it contains less than 5gm/l which according to standards classify the paint as such. (www.hemporium.com, 2012)

5.4.2.5) Lighting:

The internal lighting of the house consisted of strips of LEDs due to the energy saving properties found in LEDs; in addition to this the lights highlighted the texture of the hempcrete walls thus creating a natural finish. All other internal electric appliances used were specified as energy saving. (www.hemporium.com, 2012)

5.4.2.6) Power Supply:

A highly sophisticated solar power supply is used in the generation of energy for the house. This system also provides heating and cooling. (www.hemporium.com, 2012)

5.4.3) Specifics about the Project:

Some specific details and facts about the project according to (www.hemporium.com, 2012) include the following:

- ✿ The hemp used in the walls which accounted to 50% was grown between four and five months without the use of agro-chemicals
- ✿ The hemp plants grew to a length of 4 meters high within the period stated above and once again in must be borne in mind that hemp is a cousin of narcotic marijuana, the hemp used in this project consisted of 0.3% THC therefore establishing it as legal in the country it had been imported from.
- ✿ Hemporium has aimed at promoting the use of hemp in South Africa since 1996. The Hemp House has been constructed in an effort of showcasing the potential that hemp has to offer with an objective of gaining the attention of government to slowly start amending the legislation towards hemp in order to create jobs, provide housing and nutrition.
- ✿ Over the past year permits have been issued by government to grow hemp in 700 hectares, but mostly in the Western Cape
- ✿ The objective of using hemp as a major building material was found in the deviation from conventional materials, which are produced from mining and extraction methods, towards a natural renewable material.
- ✿ The house was constructed according to a method known as modular building which basically means building in phases. The majority of materials used where produced off sites which lead to less fuel used in transportation of individual materials, building times were also decrease by 2-4 months by using this method and hence resulted in saving costs.
- ✿ The planting of trees around the house was encouraged with an aim of balancing out carbon emissions
- ✿ The house was designed to have a “normal” appearance although consisting of hidden” green” eco-friendly secret advantages, creating the point that a building does not have to look “green” to be “green



Figure 19: South Africa's first hemp home in Noordhoek, Cape Town during construction (www.hemporium.com, 2012)



Figure 20 The Hemp home orientated to achieve maximum benefit of natural heating and light. (www.inhabitat.co.za)



Figure 21 Interior and exterior views of the hemp home. Outside gardens add to the natural emphasis. (www.inhabitat.com)

5.5) Summary and Conclusion:

It is clear from the research presented at the beginning of this chapter that a hemp industry does certainly exist in South Africa and has so for a number of years. Hemp had been used for medicinal purposes in South Africa for centuries until becoming outlawed in 1903 however since 2009 efforts are being made towards the tolerance of the plant. The hemp market in South African is functional although due to legislative restrictions on the crop, the raw hemp is imported and then processed in South Africa. The processed goods are then exported mainly to other African countries. Products of hemp manufactured in South Africa are mainly for domestic use such as soaps and clothes.

This chapter highlighted the fact that there are three Acts that prohibit and restrict the use and cultivation of Cannabis in South African, these Acts are namely:

- **The Drug and Drug Trafficking Act. 140 of 1992.**
- **Medicines and Related Substances Act 101 of 1965. Section 22A (9) (a)**
(i)
- **The Environmental and Conservation Act. 73 of 1989.**

The perception of hemp amongst the public and built environment professionals was established in the third section of this chapter. The research proved that the majority of people are unaware of hemp as a versatile crop with excellent properties and view it based on its narcotic elements.

South Africa's very first hemp home completed in November 2011 was discussed in the forth section of this chapter. The house has been dubbed as the most sustainable home in the country due to the properties of hemp used in the major construction elements coupled with the most modern sustainable designs and equipment available today.

To conclude a safe establishment can be made that a hemp industry does unquestionably exist in South Africa however its full potential is restricted by legislations set by government. The profits of the hemp markets in South Africa shall increase drastically if the crop is cultivated at a commercial level on a local basis. The South African government has however shown some leniency in the matter over the past few years which does indeed look promising for the future of hemp in the country.

5.6) Hypothesis:

In culmination of all the research and facts presented in this chapter, the hypothesis can be tested by answering the question of **“Is there a relationship between the economic factors of hemp construction and the South African legislation regarding Cannabis in addition to the general perception of hemp?”** The answer to the question is obviously yes. The cost of hemp construction in South Africa is substantially high due to the fact that the hemp hurds need to be imported into the country. Likewise the cost of building sustainable houses is also high due to the cost of modern sustainability enhancing equipment; however the expenses incurred by such equipment can be recovered by means of savings in energy usage over the useful life time of the building. The expenses incurred by importing the hemp hurds can drastically be reduced if the crop is grown at a commercial level in South Africa thus eliminating the recovery of such expenses. The attitudes and awareness towards hemp in South Africa is yet another major factor that needs to be addressed. The South African Government (Legislation) and general public need to stop associating hemp with its narcotic cousin marijuana as the two plants are completely different from one another. The hemp industry in South Africa can be expanded vastly if major companies, such as certain petrochemical companies, show interest in the crop and began implementing it into their “green programme” initiatives. Hemp construction can also prove to be a possible solution in solving the current housing problem in South Africa, people could literally grow their own material for houses in 4 -5 months and begin constructing instead of waiting 8-10 years for a house.

From this assessment the hypothesis can partially be accepted with the final remark stating that sustainable hemp construction is possible in South Africa however it is not economical at this stage due to negative perceptions of hemp.

Chapter 6

Conclusion:

In conclusion of this research report, the main problem stated in Chapter 1 can now finally be addressed by summing up the findings of the various sub problems

• The Main Problem:

Will hemp building be sustainable and economical at the same time?

6.1) Introduction:

At the beginning of this research report hemp was introduced as a versatile mainstream robust crop otherwise known as *Cannabis Sativa*, the non narcotic cousin of Marijuana. The uses of hemp dated back to more than 8000 years ago until becoming restricted and in some cases totally eliminated due to corporate sabotage prompted by the “*Reefer Madness Campaign*” of the early 1930s. The uses of hemp ranged from clothing to medicine and now to sustainable construction. The renewable and environmental benefits of cultivating hemp were furthermore established in Chapter 1, proving that growing hemp is beneficial to the environment in more ways than one. The facts presented in Chapter 1 direct one towards the question of: “could hemp have been the possible solution of preventing pollution, global warming and the current dire state that the world finds itself in today?”

6.2) What makes hemp construction possible and what methods are required?

The primary building material produced by hemp, known as hempcrete, was fully discussed in the second chapter of this report. The application of hempcrete is very much similar to the application of conventional concrete as well as the spray on application of shotcrete therefore concluding that no special training and skills are required. Hempcrete can be applied to walls, floors, roofs, renovation of external facades, ground floor slabs as well as suspended floor.

Construction was found to be much simpler and faster by moulding hempcrete into hemp bricks and hemp blocks although it must be noted that hemp blocks are of a non load bearing nature. A further method of construction is found in pre-manufactured hemp particle boards used as cladding around frames. All these types of hemp building materials contain excellent insulation properties hence contributing to the sustainable qualities concerned with this report. The use of natural lime in the mixture furthermore enhances the sustainability and environmental benefits of hemp construction as lime has the ability of absorbing carbon dioxide gas over its life time. The research conducted in Chapter 2 establishes that construction using hemp is indeed possible, although believed to be the contrary by many; in addition to this the materials are sustainable in both the manufacturing process and during the useful life time of the building once constructed.

6.3) What is the science behind hemp construction, its sustainability factors and Design Principles?

In order to fully understand the sustainability of hemp homes the science of the hemp hurds needs to be fully understood hence the purpose of this chapter. The research concerned with this chapter exposed the ability of hemp hurds to release stored heat once the air around it cooled therefore resulting in savings of energy usage during winter months. Previous research conducted in England proved that hemp houses are competitive alternatives when compared to conventional masonry homes, equalling and in some cases beating the properties of masonry. However the costs of such hemp homes were significantly more than masonry owing to the fact that the hemp was not grown commercially. Tests stated in Chapter 3 furthermore proved that hemp construction materials are fire and water resistant. Four main design alternatives exist with regard to hemp houses however a modern and most efficient design has been established by a combination of the various designs. In conclusion the facts presented in Chapter 3 verify that hemp is a sustainable building material mainly due to the properties contained within the plant itself in addition to this, coupling the material with the correct orientation of the building and most appropriate design could create a highly beneficial and sustainable home.

6.4) What possible Finishes and other Products of hemp are available?

The use of hemp in the construction industry is not only limited to the construction of walls, roofs, slabs etc however it can also be used as a finish to a surface in the form of plaster. Hemp plaster is a derivation of hempcrete and is applied either by hand or spraying hence no special expertises are required to achieve this type of application. A variety of different textures can be created using hemp plaster in addition to this hemp plaster has an additional feature in which it reflects light of the walls thus creating a certain aspect of character to the room. Hemp plaster can be applied to new buildings as well as older buildings requiring maintenance however it is not advisable to plaster external surfaces. Four different classifications of hemp plaster exists namely *“Art Can mix”*, *“plaster containing gypsum”* and *“Alliance four floor mixes”*. The application of paints manufactured from natural lime over hemp plastered surfaces add an additional sustainability and eco friendly factor

Aside from the innovation of hemp plaster other products have also been created such as hemp particle boards, hemp carpets and underlays. These products contain all the sustainable benefits as mentioned before however at this stage it is uneconomical to use such products as the prices are higher due to the fact that hemp is not commercially grown as yet therefore creating non competitive prices when compared to similar products made from other materials such as timber particle boards.

6.5) Is there a relationship between the economic factors of hemp construction and the South African legislation regarding Cannabis in addition to the general perception of hemp?

The research and facts presented in this chapter addressed the crux of the matter with regard to the topic of this report with specific reference to South Africa. South African markets prefer to import hemp, process the raw material and then export the final products to other countries, the majority of which being other African countries. South African hemp product manufactures can obtain higher profits if the crop is cultivated locally however such cultivation is restricted and prohibited by three Acts of the South African legislation. The perception of hemp in South Africa is still negative

and in a way backward when compared to developed European countries. The majority of professionals in South Africa are unaware of the potential of hemp and make no distinction between hemp plants and narcotic marijuana although the two are completely different from one another yet appear the same. A clear cut characterization needs to be made between hemp and marijuana, activists protesting a cause towards the legalisation of hemp should not be classified as activists whose cause is the legalisation of marijuana, the two parties are fighting for two separate causes although a leniency in the latter may lead to a leniency in or even total acceptance of the former.

November 2011 saw the completion of South Africa's first hemp house. The house has been hailed as South Africa's most sustainable home primarily due to the hemp used in the construction as well as the numerous sustainability features found in elements such as the windows, lighting and power source but to name a few. The intention of building such a house was to show case the potential of hemp and how beneficial it can be in creating a warm and organic house hold. The cost of hemp used in the construction was particularly expensive as it was imported from Europe, the cost of the other sustainability features were also expensive however these cost can be recovered in energy savings throughout the life time of the house.

6.6) Further Research Suggestions:

The following points resemble topics and issues that have not been fully discussed and acknowledged in this report.

- Hemp Construction on a commercial level
- Low cost housing units for the RDP programme using hemp
- Tests and research conducted at the CSIR with regard to hemp
- Different alternative innovations of using hemp in construction asides from hempcrete
- Alternatives of using timber frames such as the use of light steel framing and the impacts thereof
- Different manners in which hempcrete can be applied
- The future of hemp construction in South Africa

6.7) Final Conclusion:

The final conclusion of this research report can now finally be addressed by taking into consideration all the facts presented in this chapter as a summary of the preceding chapters. The answer to the question of; **“Will hemp building be sustainable and economical at the same time?”** can be concluded in a two part contrasting answer of **YES** and **NO**. The research of this report indicates that hemp is a sustainable building material due to the fact that it is natural, renewable and can be grown in a short period of time, in addition to this hemp has energy saving benefits once used in construction due to the structure of plant and its ability to release heat during cold periods. However in order to ensure that a house is extremely sustainable a number of other sophisticated sustainability devices need to be incorporated along with the hemp construction. At this current point in time hemp construction in South Africa is uneconomical as the hemp required is imported from the west. A simple solution in remedying this issue lies in the amendment of the South African legislation in permitting the growing of hemp commercially. The South African climate is well suited for the growing of hemp. Growing hemp in South Africa will indeed be beneficial to the country in the creation of jobs found in the production of medicine, paper, fabric oil and food. The growing of hemp worldwide could also prove to be beneficial in aiding in the elimination of deforestation, pollution and wars generated from the greed for oil.

Hemp construction could also be a possible solution to the current housing problem in South Africa, low cost housing units made of hemp will be quick and simple to construct in addition to this a vast decrease in the amount of energy used in the informal areas will be shown during the winter months due to the release of heat by the hemp hurds thus eliminating the use of heaters or domestic fires which are hazardous. The sole reasoning behind the discouragement of hemp in South Africa is due to its association with narcotic marijuana, the perception of hemp in South Africa drastically needs to change in order for this crop to show case its beneficial potential. A clear distinction needs to be established between the two plants, the manner in which marijuana is grown is completely different to hemp hence one must not ask the question of; “Will I get *HIGH* if my house burns down??”

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