Cape Peninsula
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From the Grave to the Cradle: Exploration of Hemp as an Eco-Design Material

by

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DECLARATION

I, John Franciscus Vermeulen, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed 20-02-2008
Date

ABSTRACT

This thesis argues that the story of hemp is one of mistaken identity and focuses on the potential of hemp (Cannabis sativa L.) in a social and economic context. It also asserts how hemp with the application of appropriate technologies can be developed nationally 'new' material, with reference to examples from abroad.

The current proliferation of raw material shortages means that designers have a social responsibility to seek new ways to source and process materials for a sustainable future. Designers are the "future creators" and should prescribe materials that are not only healthy in the cycle of production, but also ensure an afterlife (recycling). The methodology employed is a combination of qualitative (such as interviews) and quantitative methods (such as statistical analysis). Life Cycle Analysis is used to study the ecological impact of substituting hemp for current materials and processes. The study interrogates the historic significance of hemp in various societies across the world with particular focus on Europe, Japan, the United States of America, Ireland and Australia.

Such information is analysed within the realities of the South African context. A vast amount of information on hemp has been published but practical information is hard to obtain in South Africa necessitating a search for definite answers abroad, mainly in Europe where there is a strong development in this field. After researching the production of the hemp raw materials and the manufacture of viable hemp products abroad, lessons could be assessed for application to the local market.

The findings endorse the view that hemp is a sustainable zero-waste material; the whole plant can be used when harvested, which makes it an ideal material on which to base an eco-design system. Hemp can be processed by utilizing either high technology equipment or by the use of locally available equipment and manual labour. It can be converted into a multi-diverse range of viable products such as paper, thatching, building material and ceiling panels. The main reason for the isolation of hemp in South Africa is the mistaken assumption that it is a drug and outlawed by our legislation. Since hemp (Cannabis sativa L) is perceived as a vilified cousin of marihuana it has lead to a blanket ban on both plants. This is certainly not warranted as hemp produces an extremely low value of the controversial hallucinogenic tetrahydrocannabinol (THC)properties which is negligible.

Key Words: *Eco-design, hemp, multi-diversity, socially responsible design, sustainability.*

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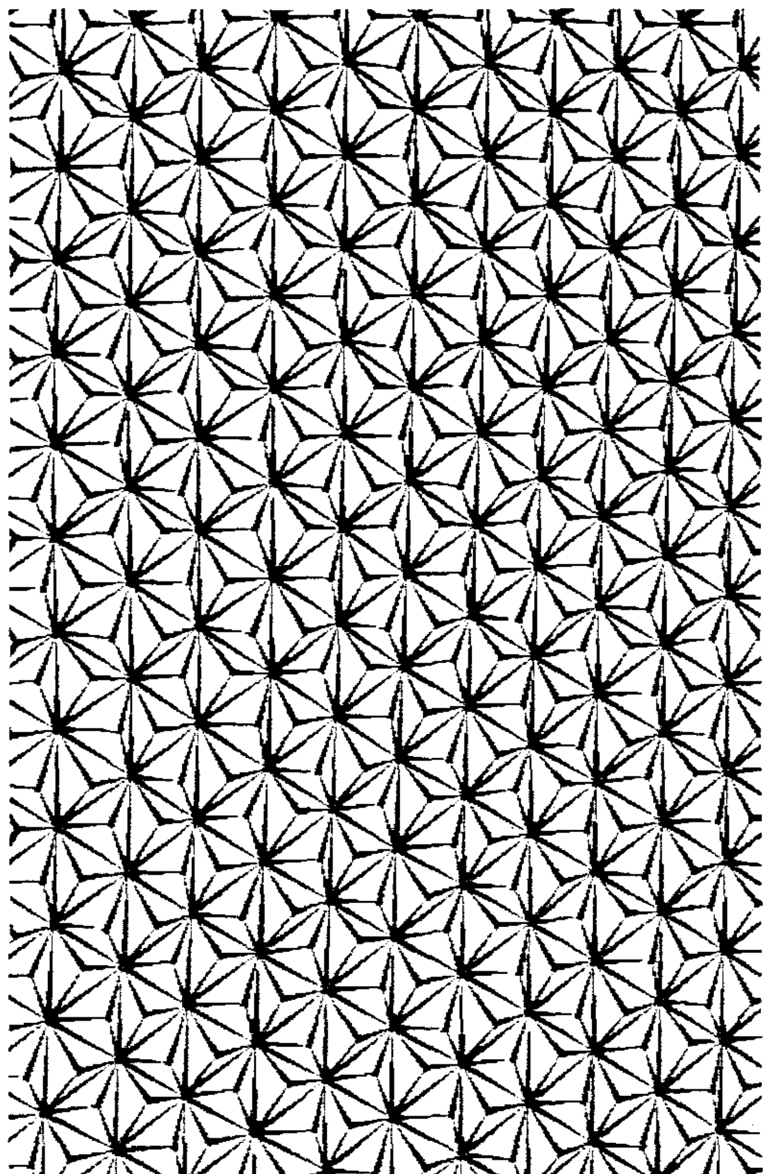
DEDICATION

To my parents who have stood by me and taught me how important it is to persevere and adapt.



The Japanese *Asanoha* pattern inspired by the hemp plant.

TABLE OF CONTENTS

CHAPTER FIVE: PRODUCTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX

Glossary

ARC- Agricultural Research Council (Brough et al. 2005:1)

Asanoha- a Japanese geometric pattern that did not borrow its shape from the plant but "literally looks like a hemp leaf (The pixel work of Mikio Inose 2007)"

Bast- the outer protective layer of a hemp plant, consisting of fibre, rugged of texture and conducts foodstuffs to all of the plant (Encarta 1999)

CBD- cannabidiol (CBD) is the main "non-psychitomimetic cannabinoid (Small & Marcus 2002)" in the THC strand

CBN- cannabinol (CBN) is the psychoactive cannabinoid found in Cannabis sativa L (Cannabinol 2007)

Cellulose- the main building block of cell walls of plants of which its derivatives can be used for making plastics, synthetic fibres lacquers, and explosives (Encarta 1999)

CPUT- Cape Peninsula University of Technology

DEFSA- Design Education Forum of South Africa

Dioecious- separate male flowers from seed that pollinate the female flower that return with seed (Ranalli 1999:21)

Eco-Design- to develop with a wider solution scope: creating products that have a minimal impact on the environment (Karlsson & Luttropp 2006: 1991)

EFA- Essential Fatty Acids (Rosenthal 1994:173)

EIHA- European Industrial Hemp Association (Carus 2006:1)

EPA- Environmental Protection Agency, a federal agency set up in the United States concerned with the safeguarding of health and wellbeing of nature including the land, water and air (United States Environmental Protection Agency 2008)

Fibre- a long slender thread or filament of a natural or synthetic material that can be spun into yarn (Encarta 1999)

Filament - a slender or long strand consisting of similar cells joined end to end, the stalk that supports the pollen-bearing anther in the male reproductive organ (stamen) of a flower (Encarta 1999)

Hectare- a metric unit of area equal to 10,000 sq m {2.471 acres} (Encarta 1999)

Hemporium- a concept store promoting hemp through the motto Innovate Educate Cultivate, based in Wynberg, Cape Town that supplies food, clothing, cosmetics and future housing

Herbaceous- parts of the plant which are fleshy and wither after each growing season as opposed to woody plants such as trees that are persistent (Encarta 1999)

Hurd- the inner woody part of the hemp stalk also referred to as the shive (Roulac 1997:14)

Hydrated lime- is made from quicklime and by adding a set amount of water causes a chemical reaction during which the oxides are converted into hydroxides and are then supplied in either a sludge or powder form (National Lime Association)

Hydraulic lime- derived from limestone that is heated; the calcium then reacts with the clay and impurities in the blend to form a unique product that has the ability to set under water or without being exposed to air (Hydraulic lime 2007)

Lateral thinking- observing a structure from outside to resolve stagnant issues but can also be used within a framework to re-pattern ideas by turning them upside down, reversal, distortion or query (De Bono 1983:46)

Living machine- a wastewater treatment system based on a biological form to mimic wetlands using plants, bacteria, snails or fish to cleanse polluted water; potential useable by-products are methane gas or edible plant (Living Machine 2007)

LCA- Life Cycle Analysis, a research-based method that aids in concept development (The Environmental Literacy Council 2005)

Lignin- an essential part of the cell walls in plants, after cellulose the most present organic polymer on Earth (Lignin 2008)

Merovingian period- ran from the mid fifth until the mid eighth century in ancient Gaul under the Salian Frankish dynasty (Merovingian 2008)

NOPI- National Organic Produce Initiative, a program developed to rebalance the gap between the second and first economies by ensuring a participatory and empowering model for African small-scale farmers in the agricultural economy (Revert 2007)

Osmosis- an often unconscious absorption of knowledge or ideas through continual exposure (Encarta 1999)

Permeable-allowing liquids, gases, or magnetic fields to pass through (Encarta 1999)

Physiology-the branch of biology that deals with the internal workings of living things and reproduction, rather than with their shape or structure; the way a particular body or organism works (Encarta 1999)

Phytoremediation- a method to remove contamination from soil and restore soil balance by means of plants (Phytoremediation 2007)

Polyactide- a thermoplastic made from lactic acid and is quickly biodegradable (Lenau 2003)

PTP™ - a thermoset resin manufactured from vegetable matter (Schmehl et al. 2007:1)

RDP- Reconstruction and Development Programme, South Africa's original post-Apartheid economic framework that seeks to address socio-economic issues such as housing provision (RDP 2008)

Retting- a partial rotting processes either through an enzyme, water or dew to facilitate the removal of the bast fibre from the woody hurd core (Rosenthal 1994:380)

SACODAS-South African Council for Organic Development and Sustainability, a united public-private partnership that monitors, designs and governs the investments and the strategic planning that are implemented by NOPI (Revert 2007)

SIVA- Sustainable Integrated Villages in Agro-ecology, a tool that is devised to utilise the NOPI principles and any other empowerment programs (Revert 2007)

SMC- Sheet-Moulding-Compound uses a press-mould to structure fibre materials and resins into a desired product (Schmehl et al. 2007:1)

Sustainability- where human interaction with nature can produce enough resources to maintain that community and their future generations without exploiting it, even after a natural catastrophe (Christer 2004:106)

THC- delta-9- and delta-1-tetrahydrocannabinol, are the main active psychotropic substances in Cannabis indica and Cannabis sativa L. (v Wyk 2000:158)

Thermoplastic- when heated they soften and can be moulded into complex cavities and rerun through the process several times (Ashby & Johnson 2005:177)

Thermoset- once shaped these bonds cannot be altered, have good dimensional strength and are resistant to high temperatures (Ashby & Johnson 2005:178)

Wabi Sabi- a Japanese term for introducing a flawed detail or idea into the product to enhance its elegance (Boinod de 2005:109)

Water glass- an adhesive (Betol 39T1) diluted in water to create a ratio of 18wt.% solids in water (Grohe 2004:353)

WCHI- Western Cape Hemp Initiative directed by Tony Budden from the Hemporium in Cape Town, South Africa (personal communication, 9 October 2007)

CHAPTER ONE
PURPOSE OF THE RESEARCH

1.1 Introduction

This chapter will explore the numerous methods that are theoretically relevant for application to data that informs this thesis. A summary which was derived from questionnaires developed for this purpose is also included.

1.2 Research Problem

There is a continuous search for sustainable production materials and methods with an eco-design focus. However, novel approaches might actually be rediscovered in old, familiar but yet often discarded solutions, whose efficacy has faded from the collective memory or has been altogether lost. This research is aimed at collating the knowledge that is internationally available on the production of hemp and by doing so begin to create a practical database to aid in the motivation of incorporating hemp to the list of desirable industrial crops in South Africa. The purpose of this research is to establish why hemp has been marginalised in this country and to justify the re-evaluation of hemp as a significant and sustainable eco-design material.

1.3 Research Question

To fulfil the set requirements for this research, empirical information will be sought to answer the following questions relevant to hemp:

- What can be done to successfully introduce hemp into South Africa as a production material and thereby translate it into a prototype product based on the Eco-Design model?
- What barriers hinder greater use of the hemp plant as a sustainable design resource in South Africa?
- How do hemp products measure up (in terms of sustainability, energy consumption and structural benefits) against popular alternatives such as plastics or other cellulose materials?
- What aids/tools are there in the detection of crop THC values?
- Are there any new manufacturing processes that could better utilize hemp as a raw material for sustainable design solutions in South Africa?
- Who in the industry is most amenable to adopting and promoting hemp-based alternatives as well as acting as a change-agent for pedagogical and professional interventions?
- Are there any social concerns that need to be addressed to facilitate a controlled (re-) introduction of hemp for mass consumption?

1.4 Objectives

The research sets to create a database on hemp, focusing on design applications and the implications on production and creation of resources specifically aimed at the developmental potential and economic growth of the Eastern and Western Cape.

The collected research material, knowledge and creativity will be merged into the conception and construction of a product relevant to the South African context.

A theoretical part of an eco-design model that will set an informed viewpoint will be applied, focusing on a specialized sustainable prototype/theory outcome that will be monitored by a Life Cycle Analysis (LCA).

It needs to be stressed that perception and approach plays a major role for the choices of materials and that a new model may evolve through application.

1.5 Delineation of Research

The boundaries that will make this potential project viable will consist of the following:

- The focus area of this research will be material processing possibilities of hemp in the Eastern and Western Cape Provinces.
- This project will merge knowledge acquired through literature and interviews and translate it in a prototype suitable for the South African manufacturing and consumption market.
- The research will be completed in two years.

1.6 Research Design and Methodology

Keeping in mind that a tacit overview of an Eco-Design structure is the main focus, a knowledge-based outcome can only be attained through awareness of potential valued interaction. As a starting point, an on-going literature review and database referencing will create a mixed topic search on hemp, focusing on all the possible inputs, based on a broadened interest in materials enabling growing potential.

It is important to ensure that all the information relevant to the eco-design examples are intrinsically linked to give an answer based on reality and information relative to the topic. This research will employ a combination of quantitative methods which involves statistical analysis of questionnaires to obtain set figures and qualitative methods through interviews which is more flexible in it's collecting and outcome (Blaxter 2001:196), though the emphasis will be on the latter. These aspects are elaborated further on in this section.

1.6.1 Research Activities

- Structured questionnaires will fulfil part of the quantitative part of the approach, with the main focus groups being designers, government representatives and material producers.

- The Life Cycle Analysis is a statistical program that aids in concept development, in this case predicting environmental impact. The LCA platform gives a bottom-up approach with an understanding that all abstracts need to be allocated, limiting the amount of numbers and including the relevant environmental effects. Damage categories should also be woven into the equation covering human health, ecosystem qualities and resources (Eco-indicator, 2006).
- A group of professionals who will be selected as a result of the field research will be approached through interviews at a later stage to form a qualitative platform in attaining information regarding hemp.

  The focus areas of the professionals will be on: plant characteristics, agriculture, process specialists, research development and other related topics that will evolve. Through these interviews a basis for a structural analysis will advance in a set of questions for further field research. The set-up of these questions is open-ended and will then feed into the database, clarifying terminologies, concepts, phrases and facts.
- A cross blending might evolve while using the LCA tool as it allows for the diverse factors to be added together in a focused sustainable eco-design outcome (Karlsson & Luttropp, 2006:1295).

As an industrial designer trained at the Cape Peninsula University of Technology, the aim of my research was to test the viability of hemp by manipulation of the actual material. During the training, broad understanding of various methods of manipulating material into a feasible product was required. A main part of the research involved applying those techniques to hemp in order to create consumer products (for example indoor furniture), be it using hemp as fabric or a plastic or a board etc. The research entailed using different forms of hemp products in order to evaluate them against one another. Also, it examined the viability of using such a product (like hemp canvas) in the Eastern and Western Cape and the infrastructure, industrial processes and tools already in place, what additional resources would still be needed, as well as the production?

1.6.2 Research Outcomes

1.6.2.1 Quantitative Questionnaire

To gain insight into the public awareness of hemp a questionnaire was compiled and handed out at the *Hemporium* stand during the Design Indaba Expo that was held at the Cape Town International Convention Centre from 23 to 25 February 2007.

Due to the international exposure and design-focused exposition, a wide range of opinions and attitudes could be sampled; from designers to visitors looking for designer products or inspiration. The questionnaire was designed in such a way that those surveyed would be given the feedback form without any information on hemp and, after filling in the front page, would be briefed on hemp upon request. After the brief, they would be asked to complete the back page and, through this, a sense of attitude change could be monitored.

There were eight questionnaires that were successfully completed, five by males and three by females. The ages varied between 16 to 45 and the response to the question on what hemp is used for indicated that people understood how diverse the hemp plant is. Answers such as nutritional value, textiles for clothing, building material, paper, cosmetics and plastics were documented. When they were asked when first they heard of hemp, the time span ranged from four to fifteen years ago.

The reaction to whether hemp should be grown in South Africa was fully supported and the reasons why it should be grown were; for job creation, a natural organic and environmentally friendly sustainable crop, potential use as a renewable energy source, a useful fibre and a natural replenisher of the environment.

When asked what they would use hemp for, the main products that came to mind of the participants were; clothing and fabrics derived from the plant, plastic, health foods and cosmetics.

The aspect which impressed the respondents most about hemp was its versatility or diversity. Further, they expressed their amazement over the durability, softness and strength of the fabric and some explained that the plant supported their sense of individuality. With regards to the final question, everyone agreed that hemp should be grown in South Africa.

From the answers derived, it can be inferred that most people understand how hemp can be used. A few indicated that they came to know about hemp through consuming it, but it is not clear whether one can conclude whether they associate the drug with the fibre plant.

If it were up to the public, they would certainly have the crop grown in South Africa due to all the benefits it has to offer; not a single person implied that it could be used as a narcotic! The complete questionnaire with the participants' answers is available in Appendix A.

1.6.2.2 Qualitative Interviews

The following is a list of individuals and organisations who participated in the interviews:

- Thierry Revert from the South African Council for Organic Development and Sustainability (SACODAS) has been the main source of inspiration for this paper and was interviewed to tap into his vast knowledge and insight on hemp and other relevant topics.
- To insure a coverage of local production industry, interviews with Tony Budden from The Hemporium, Cape Town was equally important as he is involved with importing hemp products and is locally manufacturing a clothing range from fabric sourced mainly from China.
- An interview with the head of hemp studies, Wilma van der Merwe at the Agricultural Research Council (ARC) in Elsenburg helped shed light on hemp growth and clarify his and governmental views on the topic.
- Processing of hemp was covered by Mr Heiwegen, the production manager at Hempflax, a company in Oude Pekela, the Netherlands who grow and process hemp into stalk and fibre products.
- Ronald Glas of the Cannalyse testing kit was interviewed in Wageningen, the Netherlands to acquire the technical and chemical knowledge of hemp.
- At Natural Powered Speed Products (NPSP) based in Haarlem, the Netherlands, Neils Harenbosch was able to explain how hemp is processed into composite products previously made with glass fibres and the impact it has on production.

1.7 Summary

Having clarified that mainly qualitative methods (as well as appropriate quantitative methods) were used to acquire knowledge to accomplish the research goal for this research; the focus in the next chapter will be on the biological structure of the plant and specific requirements for optimum hemp growth.

CHAPTER TWO
HEMP PLANT ANALYSIS

2.1 Introduction

This chapter will analyze the sowing and growth requirements of the hemp crop as well as the harvesting and preparation methods applied prior to it being turned into a useable raw material.

2.2 Plant Physiology

The cellulose building block of plants' organic matter – carbohydrate lignocellulose – is a chain of glucose molecules that are derived from the ability to turn minerals, with the help of photosynthesis, into a monosaccharide sugar (Conrad 1994:98).

Hemp is an annual dioecious – male flowers pollinate the female flower – and is considered a weed in some parts of the world due to its easy adaptation to the worst soil and climatic conditions (Ranalli 1999:21). The hemp plant is a member of the mulberry family, Moraccae, to which the Osage orange, the mulberry, and the hop belong. Being an annual herbaceous plant that grows from seed, hemp stalks are dense and rigid (Figure 2.2.1) and reach anywhere from 1-5 meters in length.

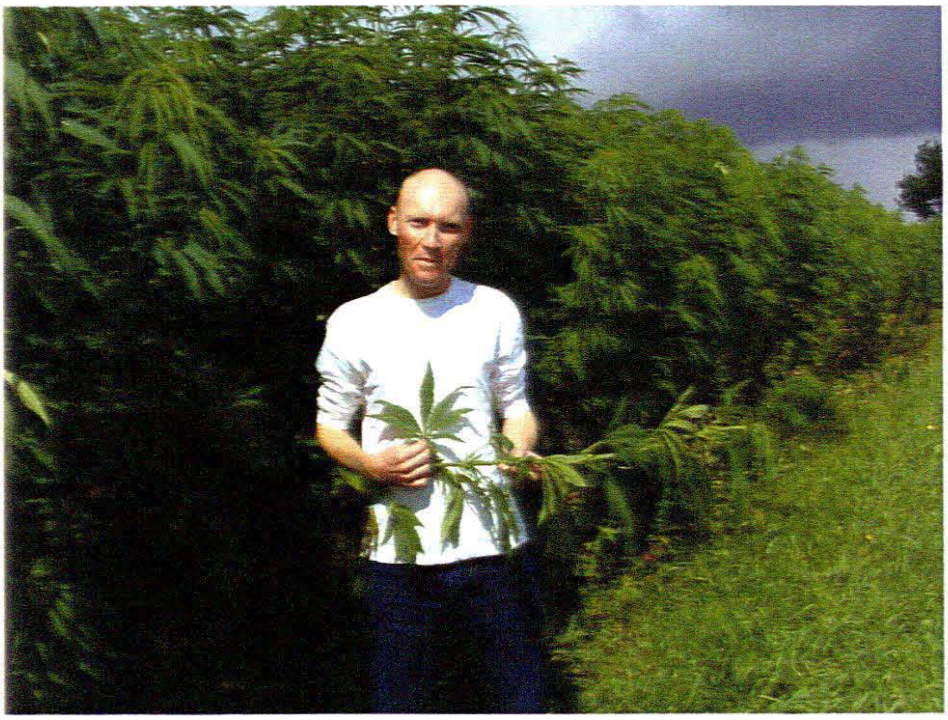


Figure 2.2.1: A hemp field in the Netherlands

(Vermeulen, 2007)

The stalk is four-cornered and can attain a thickness of anywhere from 1-6cm and is more or less fluted. Well distinguishable nodes grow at intervals of 10 to 50 centimetres along which sprout rich green palmate leaves, ranging from three to 11 odd-numbered leaflets (Rosenthal 1994:340). The average technical length of a hemp fibre is 2m, but the elementary short fibre varies between 15 to 55mm and has a thickness of 16 to 50 microns (Dijkmeijer 1947:62).

The hurd (Figure 2.2.2) is hollow and found behind the bast of the plant that consists of the following chemical composition: 67% cellulose, 4% lignin, and 13% hemicelluloses (Brough et al. 2005:12).

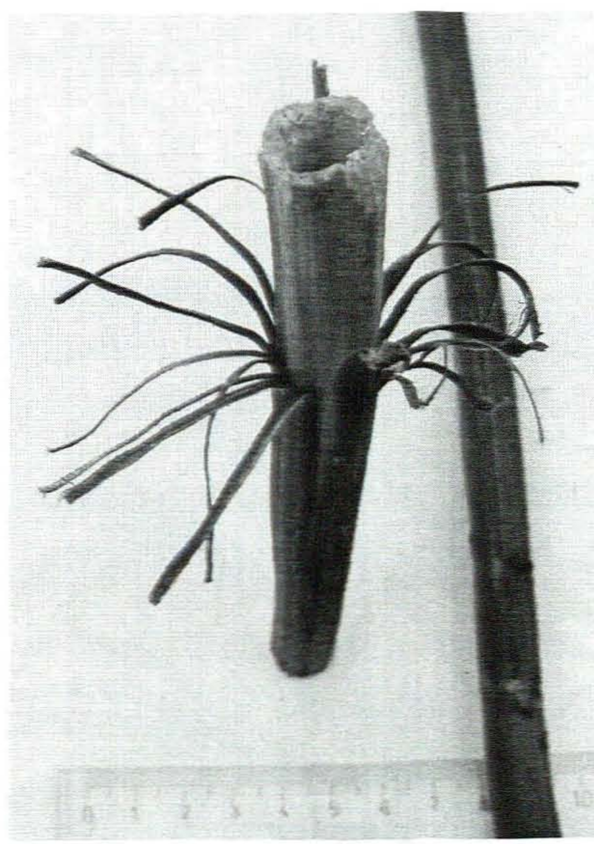


Figure 2.2.2: A hemp stalk with the bast stripped from the hurd

(Vermeulen, 2007)

The slender male plant (Figure 2.2.3-1), also called a staminate, carries a five-stamen flower and produces an abundance of pollen that pollinates the female seed to produce a pistillate plant, which seeds best with four plants per square metre (Ranalli 1999: 2). The male plant dies after pollination but the hundreds of calyxes of the female that have been fertilised turn into seed and ensure that the plant lives another two months (Conrad 1994:62).

In 1978 Chailakhyan & Khryanin based in Moscow investigated how the sex of the plants could be altered through cutting the shoots off after three main leaves had developed. When the cuttings were put into water to re-shoot, the adventitious roots were removed, which then caused 80-90% of the plants to become male. In contrast, when the roots were allowed to develop further, then up to 80-90% of the plants turned into the female species. About 80-90% of de-rooted male cuttings that were then treated with 6-benzylaminopurine turned into female plants (Chailakhyan & Khryanin 1978:185).

Figure 2.2.3: *Cannabis sativa L.*
1. male flowering shoot, x⅔; 2. male inflorescence, x3; 3. male flower, x6;
4. stamen, x6; 5.female inflorescence, x4; 6. Female flower, with bracteole, x6;
7. female flower, x6; 8. fruit, enveloped by bracteole, x4; 9. achene, x4.

(Verdcourt 1975:2)

2.3 The Sowing

The most suitable seeds for the South African climate are Novosadska from Yugoslavia, Kompolti from Hungary, and Futura-77 from France and should be imported with the necessary certificates to ensure authenticity (Brough et al. 2005:7). The soil temperature should be between 10° and 12° Celsius or higher to guarantee proper germination and have the hemp seedlings appear within 10 to 14 days (Gjaltema 2003:9).

A thousand kernels (Figure 2.3.1) or seeds can weigh anything between 9g and 25g (Rosenthal 1994:128): in my own research, they weighed 17g.

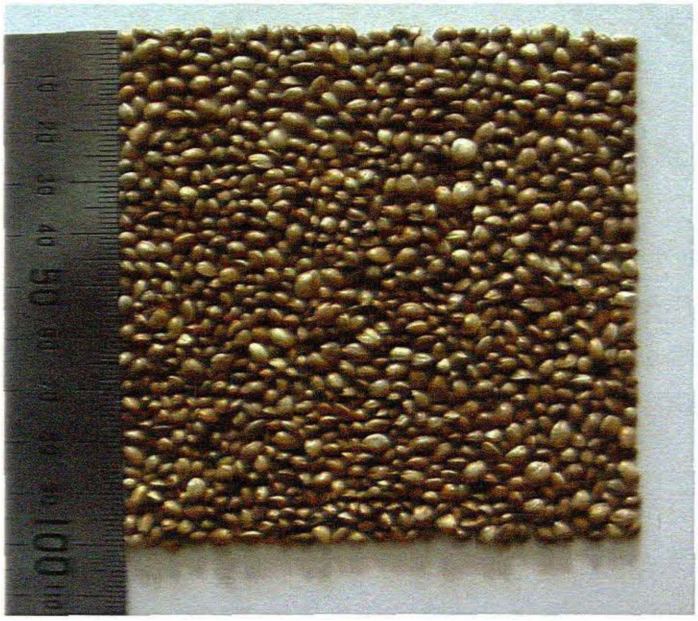


Figure 2.3.1: 1000 hemp seeds

(Vermeulen 2007)

The outcome of the ideal crop is based on several elements that can play a mayor role, but the most important one is the exposure to long periods of daylight. The female plants stop growing and start to reproduce when the daylight exposure becomes less than 12 hours of sun exposure (Conrad 1994:169).

Through experimentation it seems best to sow the male seeds close together at a distance of about 10cm apart, which ensures vigorous growth when a fibre is required from the plant (Allin 2005:23). To achieve a high fibre volume, an amount of 80 to100kg of seed is used per hectare. To grow crops for seed reproduction purposes, an amount of 50kg sowing seed per hectare will suffice and the spacing between the plants is required to allow a sufficient area for the female plants to spread out (Dijkmeijer 1947:63).

With a sow-rate of 60kg of seed per hectare, there can be a variation in yield ranging from 40 to 200 plants (Rosenthal 1994:129). Hemp can be sown at a depth of 4 to 5cm in none-crust soils or in numerous other types of soil, even during late and dry periods; 6cm will enhance the growth success. It has been proved that for every extra 2,5cm of depth the seed is planted, an extra 24cm of growth in length will be gained (Loosjes 1823:3). Due to experience, Hempflax advises a sowing rate of 35kg per hectare, with a width similar to that used for wheat, and at a depth of 2cm. The deeper the seeds are sown, the lower the crop rate (Gjaltema 2003:8).The best time to sow in the Eastern Cape is between October and November, which results in plants with a high fibre yield (Brough et al. 2005:20). However, according to Wilma van der Merwe who runs the research program (personal communication, September. 19, 2007) at the ARC centre in Elsenburg, the beginning of November is best.

The hemp plant loves the sun and grows best with an abundance of it, the mid point of its growth should fall on the 21st of December – the longest day – explains Wilma; who conducts all the agricultural experimentation on hemp for the ARC in the Western Cape. The seeds are sown by means of a pneumatic seed drill to ensure an even sow rate with the required sowing width (Allin 2005:23). From experience, some wheat growers have achieved a yield increase of 10% or more in their winter crops after a rotation with hemp (Roulac 1997:11).

2.4 Soil and Growth

Hemp does not flourish in soil that has high clay content, is still or impervious, gravelly, or light and sandy. A naturally drained, moist, clay loam or loose textured soil rich in compost consisting of vegetable matter or manure, but not acidic in reaction, is an ideal base for a successful crop (Rosenthal 1994: 354).

The leaves contain 50% nitrogen and tend to wither from sunlight suffocation if the planting is too dense. The fallen, withered leaves create a self-mulching cycle that enriches the soil. There are further suggestions that hemp neutralises the pH level of acid-high soil and it is ideal for aerating and rebuilding soil structure (Boy 1994). Moor soils have a lower plant yield per square meter due to the high nitrogen content that accelerates plant maturation (Rosenthal 1994:12).

Irrigation plays an important role in the complete growth of hemp. It is especially essential during the sprouting period (Figure 2.4.1), which is between three and five days after planting (Rosenthal 1994:173).

Figure 2.4.1: Sprouted hemp plants

(Vermeulen 2007)

Hemp is ideal for controlling erosion on hillsides as it anchors soil. It is also used as windbreaks due its dense growth, enabling selective breeding and providing pollen barriers. As hemp can grow a dense canopy to create a humid environment, it keeps the soil cooler than any other crop grown in rows (Roulac 1997:10). The dense canopy also prevents sun from reaching the lower parts of the soil, resulting in noxious weeds being destroyed; Canadian thistle and quack grass have been killed with this method (Conrad 1994:165).

The soil should be fertilised with about 80% compost or manure from animals such as cows, chickens, horses or pigs, and the balance should consist of chemicals. The plant will first absorb the chemicals and when these have been broken down, the natural fertilisers will have a chance to integrate into the soil (Gjaltema 2003:8). The fertilisers necessary to be added to the hemp's diet to assure a better yield consist of 80kg pure potassium, and 40kg pure nitrogen per hectare (Dijkmeijer 1947: 61). However, Hempflax advises 120kg of nitrogen, 140kg potassium, and 80kg of phosphate. The nitrogen level should not be too high otherwise the plants compete too much for sunlight and the result will be a thin yield (Hempflax Argo BV, 2003:7).

The hemp plant is an ideal candidate for Phytoremediation; it is suggested that it can remove contaminants from water in the soil, pesticides, and contain, degrade or eliminate metals and a number of fuel-based pollutants that are Environmental Protection Agency (EPA) listed. This method is an inexpensive, efficient and naturally clean way in comparison to the lengthy, expensive method of excavating the soil (Blair 2001).

2.5 Harvesting and Yields

After sowing, the males and females can be harvested within 115 days, but the seeds will not have ripened yet and the plant has not matured, which will produce a soft and lighter coloured fibre but of a weaker strength (Conrad 1994:169).

The male plant will bring forth an even stronger yet coarser fibre after flowering and when left to lose its yellowed leaves. If a good seed crop is required, the males are removed from the field after pollination to ensure more breathing space for the female plants, which will expand their side branches (Dijkmeijer 1947: 64). Female plants can be left in the field through the winter, resulting in exceptionally good hard fibre, but they stand the chance of loosing all their seeds to the birds (Conrad 1994:169).

During a growth period of 130 days an average of about 8 to 10 ton of stalks can be yielded from a fertile hectare of land (Pallesen & Andersen 2002: 65). A full-grown plant consists of approximately 10% root, 15 to 20% leaves, 60 to 70% stem, and about 5 to 15% seed (Ranalli 1999:75). An amount of 16% fibre can be obtained from a stem. Ten percent of these will be long and 6% short, while the rest of the core – about 84% – is woody hurd (Dijkmeijer 1947: 68).

2.6 Plant Retting

Without the retting process, the fibre in the bast of the stalk will be hard and almost unworkable. The retting process ensures that the lignin gums surrounding a long narrow plant cell – a major component of the plant's supporting and strengthening tissue that binds them together – is partly dissolved and detached from the fibres to aid in bast removal. There are numerous methods to accomplish a retting process; the first is to submerge the harvested plant in still standing water, either in tanks or in streams for about 10 days. When the water is warm and filled with bacteria, the process is accelerated (Ranalli 1999:74). This method is a highly contaminating process to the water and should be avoided, as it was already known and stated in the *Edinburgh New Dispensatory* from 1794 to be "violently poisonous, and to produce its effects as soon as drunk (Conrad 1994:12)."

The second method requires the freshly harvested stalks to be laid out parallel on the field and relies on nature's subtle ways of working by means of dew. This method is slightly more labour intensive as the stalks need to be turned over at least twice (Gjaltema 2003:9) during the process to ensure proper moist contact over the entire plant. A well dew-retted stalk turns to a brown/grey colour after about 10 to 30 days, depending on the thickness of the stems (Ranalli 1999:74).

After the stalks have been retted, they are tied in a bundle of about 15cm in diameter and placed against one another – seven to eight bundles – to ensure proper wind circulation and sun contact. Setting out the stalks on the field for 10 to 12 days ensures a good dry and well-coloured fibre due to natural bleaching by the sun (Dijkmeijer 1947: 65).

A third option is adding an enzyme to the full-grown plant after harvesting. This aids in the bast release, just as the dew and water-retting process does and will deliver a soft and lustrous fibre. The Canadian-based Hemptown has developed an enzyme technique called CRAILAR that has been successful in obtaining very fine fibres from the bast, enabling them to create cloth that is comparable with cotton (Hemptown 2006).

Chemicals are also used but are difficult to remove and hence have a continuous, injurious, and deteriorating effect on the fibre (Rosenthal 1994:367).

A warm water retting process similar to the method used for flax is suitable for hemp but consumes energy. If the retting process is too short, the fibres will be difficult to split due to the pectin that still holds them together and will result in a rough fibre (Dijkmeijer 1947:68).

A well-retted plant will have a white fibre that will separate easily into the bast and the hurd and, when the fibres are divided, they are individual, fine and long over the whole plant's length.

It is very important to stop the retting process when the desired quality is achieved. It is also essential to dry the crop before it goes into storage to prevent further degradation of the fibre; the moisture content should not exceed 16% (Ranalli 1999:75).

2.7 Separating Materials

An average amount of fibre that can be obtained from a stalk of hemp is 25 to 30% (Pallesen & Andersen 2002: 65). There are numerous ways to separate the woody hurd core from the fibre; this is called scotching. The first method is by means of breaking, where the stalks are passed through fluted rollers or a "breaker".

Another way is by beating the stems and passing them through a set of rotary blades. Hackling is a method by which the woody parts are removed by combing the plant, resulting in a continuous aligned bundle of fibre "sliver" ready for spinning (Ranalli 1999:75).

The *dust* that emanates from the processing is rather dangerous; it is capable of *exploding* and the utmost care should be taken to avoid fire! (Stoppelenburg 2006:20).

2.8 Summary

The hemp plant is versatile and adaptable to almost any surrounding and can be planted in a set number of configurations to grow into a desired crop. The relatively short growth period of the hemp, requiring a minimum of fertilizer and no pesticides indicates that the plant has a positive ecological impact on agriculture and can be irrigated with effluent if the seeds are not destined for human consumption. Now that it is clear how to produce the hemp plant, an exploration of the plant's value to society will be explored.

CHAPTER THREE
OVERVIEW OF HEMP

3.1 Introduction

The choice of materials for new products is of major concern when the impact on the environment is taken into consideration, especially when the raw material is based on a petrochemical. This is particularly pertinent when viewed against the influential role that design plays in the world of product development and the resultant global pollution, while resource availability has become the main drive to reconsider if this is a healthy road for the future.

"From the Grave to the Cradle" is a concept that is developed in this paper to explore two significant points. Firstly, it can inform a more progressive legislation to reverse the demise of hemp production in the Western World as well as in South Africa. By using a consultative forum to engage, inform and educate future generations, government might be willing to re-evaluate its stand on hemp and alter the relevant legislation to facilitate the reintroduction of viable hemp production and manufacturing industries. Secondly, hemp can help in the revitalisation of our damaged planet, kindling it back to health, thereby securing that future generations inherit a *habitable* earth.

This concern is not as distant as it might sound at first, as time is of the essence if we as inhabitants of this damaged planet are to stem the slide towards ecological disaster. We are witnessing a crisis of grave proportions and must act without delay. On a more positive note, the answer is within our grasp, but it will require a concerted effort by all Earth's denizens, and robust political goodwill and leadership from all leaders. The logical question then is why the hemp plant is not presently used as a sustainable design resource in South Africa?

3.2 Setting

In the *Oxford Advanced Learner's Dictionary*, *cannabis* is described as "a drug produced in various forms from the dried leaves and flowers of the hemp plant, smoked or chewed" (Hornby 1997:162). Unfortunately, such statements tend to be misleading and often create a blurring line between marihuana and hemp. The hemp plant is a distant relative of the *Cannabis sativa L.* strand, very much confused with the marihuana *"dagga"* plant we all know so well. Presently in South Africa there still appears to be misunderstanding of what exactly the hemp plant is due to the osmosis of hemp being marihuana.

The stigma seems to revolve around the dangers of the hemp plant as a result of a minimal amount of tetrahydrocannabinol (THC) (Encarta 1999), which gives rise to the hallucinogenic "high" found in the locally named *dagga; Cannabis sativa L.* and *Cannabis indica*. The main substance (THC) that causes the altered state can mainly be found in the flowers of the female plant that can be either smoked or taken orally. When we measure the THC value, marihuana scores an easy 10% and higher, while that of hemp can be a controlled crop with a predictable THC that will reach a maximum of only 0.05% (Glas 2007).

Figure 3.2.1: An industrial hemp crop

(Vermeulen, 2007)

Currently there are three perspectives to the South African legislation that prohibits *Cannabis sativa L.* – industrial hemp (Figure 3.2.1) – from being grown as a commercial crop. Firstly, the Department of Health has to issue permits, yet it only allows hemp to be cultivated for experimental purposes. It is reasonably easy to distinguish physically between hemp and *marihuana*; the leaves of the hemp plant are very narrow and the plant grows very tall, while the *marihuana* leaves are wide and the plant is short. In South Africa, the law stipulates that the THC value may not exceed a level of 1% (Brough et al. 2005:12), whereas the international drug potential threshold is 0.3% (Rosenthal 1999:46). Secondly, the Department of Justice treats hemp as an equivalent to marihuana, hence declaring it a drug. Thirdly, the Department of Agriculture classifies hemp under the Invaders Act 2 and bans it from being grown without supervision.

The first requisite is to tackle people's misconceptions regarding the plant before this potential "eco-saviour" can be saved from total banishment from our agricultural fields. Further, there is a need for sustained "local consumer pressure" to be exerted to force the government to reassess its position on the hemp plant (Bethlehem & Goldblatt 1997:219).

3.3 Drug Alleviation Approaches

A few methods can be employed to create a preventive or educational approach to the drug issue that is so much focused on in our current legislation.

The approach of the Dutch government has taken on a slightly more tolerant and fruitful outcome, where the legalisation of *Cannabis indica* and *Cannabis sativa L.* with higher THC content was enforced; it proved that drug use, especially under hard drugs users, did not increase. It is often the misconception that when people are exposed to soft drugs there is a tendency to want to step over to something more powerful. With social control and legal sales there is a better overview as to what is consumed by recreational drug users – the 3% continuous users did not increase either. In addition, those who are prone to addictiveness will be openly welcome to share their problems without judgement and stigmas (Robinson 1996: 196).

During a visit to Hempflax- a company in Oude Pekela in the Netherlands, that cultivates hemp crops for seed and fibre production, Mr Heiwegen, the production manager explained that the company could supply seeds that "come with a certificate stating what the expected THC value will be". If there are any doubts about the THC in plants, female plants can be harvested before they can bloom, because it is this string of the hemp plants that carries the potentially present "high" THC resin.

> Heiwegen explains: "Keep in mind that it is only the female flowers that carry the THC in marihuana, which can be used for medical or recreational use, that is, if they have the higher level of the THC. The hemp is not suitable for recreational or medical use. That is why we grow it on open fields without fences, but then our government does not have such an issue with it either. However, they still have to issue permits for the commercial hemp crops" (personal communication, 30 July 2007).

Ronald Glas (personal communication, 28 June 2007), a molecular biologist, developed a kit called "Cannalyse" to aid in the determination of the fingerprint of cannabis specimens. However, he starts by stating that marihuana is a soft drug, not a hard drug, which means that it has no harmful effects on the body and it is not physically addictive compared to alcohol or heroin. There are two types of marihuana, the *Cannabis indica* that is a sleep inducer and the THC in *Cannabis sativa L.* that is a natural upper, as Glas describes it, and it enhances the state of the mind you are in; it is a natural particle just like aspirin that the body does not experience as a toxin. Until now, no laboratory animals have passed away after being treated with marihuana. More importantly, nobody has ever died from using cannabis by itself. When compared with other body altering substances, THC is the only drug that scores positive on all three levels of sexual activity, these being lubrication and orgasm for women, and erection for men, whereas cocaine or alcohol have only one positive point.

> Glas explains that the wrapper in medicinal marihuana should read, "Warning, marihuana is a natural medicine, the side effects are small, but may include a dry mouth and a euphoric feeling" (personal communication, 28 June 2007).

With such few side effects, marihuana is ideal for pain relief and adds to the patient's sense of a positive outlook. Glas does understand why the pharmaceutical companies see this as a threat and they devote so much effort through publicity to create a negative image around the drug. Glas explains that if marihuana was used as a substitute for current medicines, "80% of all medicine sold globally today could be replaced!"

The "mini-laboratory" (Alphanova 2007) called Cannalyse (Figure 3.3.1) requires no chemical knowledge; one just follows the few simple instructions and within 10 minutes the results are ready.

> Ronald explains in his laboratory in Wageningen, the Netherlands, "I developed this on my kitchen table with some experimentation and acquired knowledge from my chemistry studies to develop this affordable patented testing method" (personal communication, 28 June 2007).

This might explain why the kit is so easy to use as it was developed on the kitchen table. Firstly, a sample of only 100mg is required; either a seed or the corner of a leaf or stem is placed in a vile and 1ml of extraction fluid is added before being sealed. The vile is shaken to separate the cannabinoid oils from the solids.

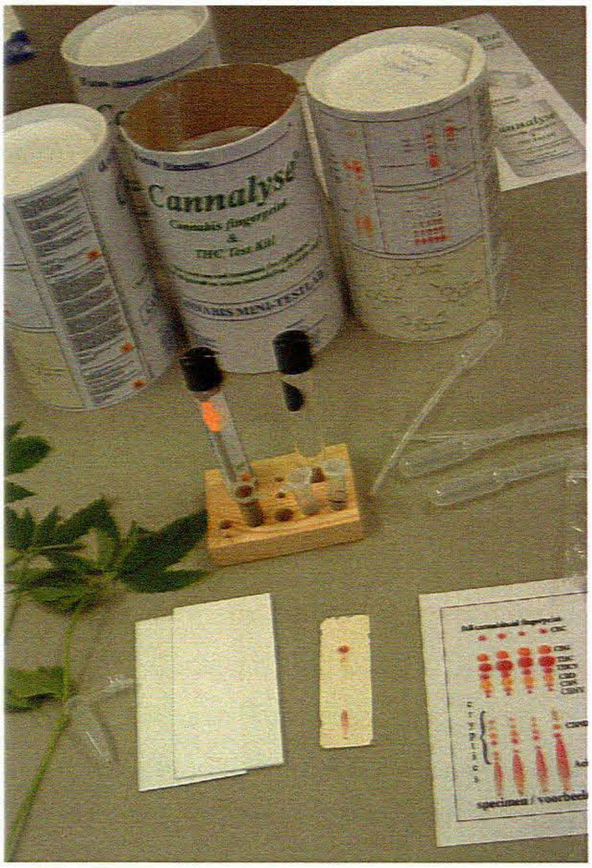


Figure 3.3.1: Cannalyse, the Cannabis fingerprint and THC analysis kit

(Vermeulen, 2007)

By using a capillary tube, the dissolved sample is drawn up and placed on the green spot on the lower part of the prepared plate – for thin layer chromatography (Alphanova 2007) – while the bottom section is submerged in a *running* fluid. The *running* fluid runs upward between two layers on the plate and takes along the cannabinoids, which then separate on to their acidic counterparts on the plate and become visible according to their intensity present in the sample. To fix the plate, a spray consisting of a powder dissolved in water is applied.

> Ronald Glas explains: "Besides the THC value that can be measured from as little as 0.0001%, it is the cannabinol (CBN) value, which is evidently the substance in combination with THC that insures the long-lasting, 'high' feeling and can be read from the plate."

Without the CBN it seems that the THC on its own has a short 'high' that is comparable with the rush from nicotine in a cigarette, which only lasts for a few minutes. Through experimentation it became apparent that the cannabidiol (CBD) has a negative effect on THC absorption and it is required to be above two parts to one THC in order to pass the European standard requirement for classification as hemp (Callay 2004:69).

In contrast to the current commercial methods that use vast amounts of sample material and are time-consuming – up to a week – and range in cost from anywhere between "€160 and €450 (Alphanova 2007)" per strand analysis, the standardised Cannalyse kit is revolutionary as it can give very accurate results for as little as €10.

3.4 History of Hemp

If we look at items such as canvas – "a Dutch word derived from the Greek 'Kannabis' (Jamikorn & Wallner 2005)" – sails on wind-powered ships, and ropes made from the fibre, it is not difficult to understand how the Dutch reached their golden age. Hemp was already a profitable crop in 1555 in numerous regions of the Netherlands, where the government asked farmers to deliver set qualities (Fels et al. 2002:16).

The cannabis plant has been used in many parts of the world for cloth and fibre purposes, as found in samples from a cave in Europe dating back to 6000 years ago. An excavation in Ankara revealed that China and Chinese Turkestan used hemp as thread and rope 5000 years ago. The medicinal and hallucinogenic qualities were then part of the culture amongst healers and Shamans (Toit du 1985:6). It was in the Han Dynasty (from 207 B.C.E. until late 220 C.E.), that Tsai Lun, the Chinese minister of agriculture, discovered in 105 A.D. the advantage of pounded hemp to create a light and inexpensive writing surface (Desai & Riddlestone 2002:47).

The first Levi jeans made in California derived from fabric spun from the hemp plant (Robinson 1996:105). The hemp fibre is not susceptible to moisture and other weather influences, giving it a unique "non-rotting" strong characteristic, which makes it suitable for wet applications such as in fire hoses, sails, tent canvas and canopies (Dijkmeijer 1947:61). The Western World had shown great interest in fibre's capabilities centuries ago and the plant was even common to the local people of the Cape in Southern Africa when fleets from the East with European navigators circumnavigated the coast in the 15th and 16th centuries (du Toit 1985:14).

Rudolf Diesel had his first prototype stationary diesel engine running on vegetable and seed oils such as hemp oil-fuel, as they are superior to petroleum. He subsequently developed this into the automobile engine (Conrad 1994:38).

In the 1930s, Henry Ford (Figure 3.4.1) actually saw the world's future evolve with the aid of hemp as the core material for his newly developed plastics and fuel derived from the cellulose in the hemp stalk. Ford was convinced that one could make things as easily from

Carbohydrates derived from plant matter as it was from the fossil-based Hydrocarbons (Robinson 1996:139).

Figure 3.4.1: Henry Ford doing an impact test on hemp bodywork

(Small & Marcus 2002:303)

Besides Ford, numerous futurists and organic-based engineers today are convinced that at least 90% of our fossil fuel based industry such as natural gas, crude oil and coal can be replaced by a renewable biomass such as waste paper, hemp, sugarcane, or cornstalks. The time has come to replace the restrictive capitalistic model with the ecological consciousness that prescribes a cleaner future focusing on a "green planet" (Jamikorn & Wallner 2005).

Hemp seeds can be used to produce oil; it has a soothing and moisturising effect on the skin, while the residue meal from the nut is full of protein (Hemp Research 2008).Further, hemp has no waste materials, it transforms waste carbon dioxide into oxygen and the whole plant can be used when harvested. Fabric made from hemp does not generate static electricity; it also creates electrically neutral surroundings of 30 meters around the root in the ground, and has the potential to neutralise ultraviolet, radioactive and electromagnet waves (Hemp info 2006).

The hemp plant produces 600% more fibre than flax and 250% more fibre than cotton per acre. In comparison, these yields can have a far better product ratio and are less detrimental to the environment. Currently there are numerous products on the European market manufactured from hemp; oil from the seed for the care of horses' hooves, paper from the hurd, and twine from the bast (Figure 3.4.2).

Figure 3.4.2: Currently available products

(Vermeulen 2007)

Until recently, the plant had an industrial application using the hurd and course fibres. An enzyme developed in the 1980s removes the lignin easily from the outer bark without compromising its strength (Suppliers of fine Hemp Products 2005). Since then *Cannabis sativa L.* seems to be a good sustainable candidate as a source of high quality, fine fibre yields just waiting to be used for numerous new options in manufacturing transformability. For example, hemp is an equivalent replacement of the glass filament used in current fibreglass resin blends. BMW and Daimler Chrysler use a number of natural fibres such as flax and hemp mixtures for interior panels in their motor vehicles for soundproofing and protection. They conclude that after a motor accident the fibre in the panels breaks into compact, reformed, crushed shapes during impact compared to the sharp, exposed edges created by plastics in current use (Hanke 2001:48).

Whereas the hemp plant can grow with virtually no fertilisers and pesticides, cotton is a crop that is considered very favourable due to its easy spinning method. However, the environmental impact seems to have been neglected. Cotton is grown on 3% of the most fertile soil, but it is then sprayed with 26% of the pesticides consumed globally. This has led to the vast contamination of agricultural groundwater and runoffs; in the United States, this has caused 15,000 lakes to become lifeless (Guy 2004).

The main reason for cotton's success came into being almost two centuries ago when the United States government started granting subsidies in order to stimulate the growth of crops. One can compare a cotton shirt in 1776 that cost between $100 and $200 with that of a hemp shirt costing $0.50 or $1. After 1830, this situation was reversed when cotton reached the same price as hemp. This was because its production costs were reduced and it became more accessible (Jamikorn & Wallner 2005).

A critical moment in history came when the hemp plant was condemned (demonised) as a drug-affiliated crop. On August 2, 1937, President Franklin D. Roosevelt signed a bill under which the plant became part of the Marihuana Tax Act, preventing hemp from being grown as a commercial crop. There are numerous rumours that William Randolph, a landowner with vast timberlands, and the DuPont Corporation conspired against hemp owing to its economic threat (Roulac 1997:51).

After World War II, the Japanese also had to submit to the laws that the Americans brought to their country when the Marshall plan was introduced to rebuild their nation. Italy, France, China, Russia and other communist states never adhered to these laws and their hemp production is currently flourishing (Roulac 1997:59).

The hemp plant has gone through a period of denial and injustice, as all negative projection is unwarranted. We should rather focus on what it has to offer to life with all its diversity in nature. After all, as stated in Genesis 1: 29-30, God gave us "every seed-bearing plant on the face of the whole earth and every tree that has fruit with seed in it. They will be yours for food (Holy Bible, The King James Version 1990:2)" and we should treat this with mutual respect and without wastage!

3.5 Summary

It is apparent that the hemp plant has played a significant role in numerous societies over a very long period of time and that it was considered a versatile resource for daily applications. Since the introduction of petro-chemical based materials, hemp has been banished to the sidelines under a drug-related banner by most Western countries due to the pressure of the United States. There are reliable cost-effective ways to determine the THC value of the hemp to allay any doubts regarding its legitimacy. The next chapter will explore the term sustainability and how it might be applicable to the material in a modern context.

CHAPTER FOUR
SUSTAINABILITY

4.1 Introduction

This chapter will explore the philosophy and models of sustainability in theoretical and practical contexts. Sustainability is a pressing issue and is high on the developmental agenda in most economies today.

4.2 Current Dilemma

In pre-industrial times people made products that derived from the earth. The said products broke down easily into the eco-system at the end of their lifecycle, thus creating a natural cycle of nutrients returning to the earth. The human species has the unenviable reputation of being the only producer that removes vast quantities of nutrients from the rich soil without replacing them in a natural usable way (Braungart & McDonough 2002:96).

The footprint we are currently placing on nature is 30% over its capacity; in other words, we are consuming for a society that actually needs one and an additional third of the planet to sustain the energy pattern to which we have grown so accustomed. If calculated, there is an average of 1.9 hectare of fair share resources per capita, but when we consider South Africa's consumption rate, it amounts to 4.04 hectare on the "world ecological footprint (Desai & Riddlestone 2002:26)."

To have a better understanding of the patterns of this society, we need to educate our children to recognise the numerous cultures with their dynamic and physical diversity. In addition, they need to learn how to relate to the world, so that we can create a better, interrelated atmosphere and awareness of the environment and its ability to carry us (Ellioti 1988:330).

On closer analysis, it becomes apparent that the dysfunction of our global inhabitants can be categorised into three levels:

- the material world; the extinction of species, polluted waterways, loss of topsoil, climate change, and mass consumption
- the spiritual and emotional well-being; measured by the rates of loneliness, divorce, drug abuse and suicides
- leaders' failure; government and other serving institutions that do not attend to the needs of the inhabitants of the planet

These issues are actually a result of a current "design" model that needs altering as soon as possible, as it is full of flaws on which we base our important economics, home and town lay-outs, as well as all agriculture and the whole of society's structure (Introduction: Ecovillages 2007:1).

The models that are currently used are mainly based on a Western concept of a line that causes a separation between human beings and nature: that nature is there for exploitation and that we hold dominion over it. Cities have a lineally structured metabolism with a one-way flow of food stuffs brought in, consumed, and then the sewage run off is considered waste (Desai & Riddlestone 2002:90).

It is as if we are leading a linear pattern that is fragmented and focused on too much detail, and based on science and mathematical structures (Sterling 2004:16) as apposed to a more dynamic system of lateral thinking. It often happens with linear patterns that data is the only means of comparison and this creates even more conflict due to the old values it is weighed up against, but does work somewhat if evaluated in an objective way (De Bono 1983:9).

4.3 Thought Restrictions

There are three ways in which the thought process maintains a linear pattern, thus restricting a successful resolution of the problems:

- If the solutions run out, an automatic gap develops in our thinking, which is mainly filled with the need to search for new ideas through *information* or experimentation in order to proceed forward.
- There might be obstacles that block our thinking or create a threshold, and the way forward is either to remove or manoeuvre around the point for forward growth. Once this point of moving beyond the obstacle is reached, the road forward is easy, as the goals become clear from the position of wanting to progress.
- The other option is when there are no obstacles in the way; the open path can then result in a speedy method, shooting past the goals that are actually of great importance. The danger of thinking that the current path is the best may lead to insufficient performance due to a mind block that obstructs the thought of openness. To avoid such a perception the path of lateral thinking is a strong option (De Bono 1983:232).

Ever since the Industrial Revolution, the source of fossil fuels took control of the energy supply, and contact with nature and its resources has caused a gap between humans and

their surroundings, giving people the feeling of having control over nature and the right to manipulate it according to their own free will (Braungart & McDonough 2002:128).
The state of the world is characterised by the desire for extravagance that, if unabated, will accelerate society's impeding downfall. If the indulgence of possessions does not move from a personal gain to a spiritual awareness and reconnect to nature once more, then this fate is eminent (Fukuoka 1978:110).

However, our ruling social institutions have given us these social hierarchic models. The latter focuses on "textual interpretations (Keeney 1994:56)" as tools to divert society from a spiritual contact with nature. Our reliance on science and the imaginative inventions we have become so subservient to leave us with monstrous machines that evoke a sense of pride, thus creating a false sense of security in the world of wholesale (Jung 1964:101).

The opposite would be true if we embrace an enduring ecological model, one that is so vitally important for our social and physical systems in which sustainability is embedded with ethical focus rather than the economic domains (Sterling 2004:13). If the scientifically acquired information gained through research, with the emphasis on an objective evaluation (the lateral process), is fed back into an educational system, the loop is complete and the insights obtained can help move a society forward (De Bono 1983:10). The idea of humbleness and aiming our glance toward nature will give new insight and wisdom, that is, utilising all the resources available today, but doing so in a serving manner and paying respect to all living organisms (Keeney 1994:63).

Sustainability is essentially a grassroots concept where the materials used, the people and their customs, energy flows, religions and needs, as well as the water and soil use should be analysed. The chemicals that affect the up and down stream of the water supply, as well as soil contamination are of crucial relevance. They have a direct impact on the local flora and fauna, and by extension, the welfare of the local community. The concept of designing products with unavoidable waste residues can be replaced with the "form follows evolution" concept (Braungart & McDonough 2002:104). This results in a new lifecycle where the shape of the design would be determined and influenced by how the waste of production and the used product actually become a valuable nutrient material that will determine the shape of the design that can be fed back into the eco-system.

4.4 Findhorn Foundation

An example of a successful sustainability project started in 1962 when Peter and Eileen Caddy, together with their three sons and Dorothy Maclean, settled in the dunes of Findhorn (Scotland). Living in small trailers, they started working with nature to provide a living for themselves. The way in which they "listened" to nature resulted in rose gardens and the now legendary 40-pound cabbages that were grown in dune sand and compost they produced from local natural waste (Living Routes 2005).

In 1972, the project had evolved into a community that was registered as The Findhorn Foundation – through a Scottish Charity – and currently focuses on training people to understand and experience sustainable design through numerous training programs. The Findhorn Foundation recently received institutional endorsement from the United Nations Institute for Training and Research (UNITAR) due to its successful living example of sustainability.

My research made it possible to visit The Findhorn Foundation in February of 2007. I was exposed to the Eco Village Training (EVT), consisting of a four-week program during which the theoretical structure they present became even more tangible through all the practical examples and hands-on experience. The model that was developed by The Findhorn Foundation bases the formula for sustainability on four cornerstones, namely economical, environmental, cultural and spiritual factors that are fundamentally interconnected.

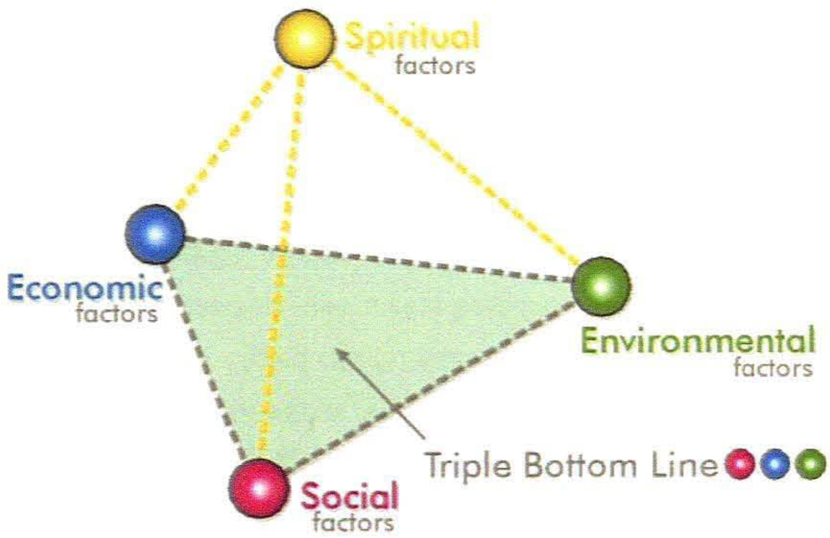


Figure 4.4.1: Sustagon model

(Christer 2007)

The Sustagon (Figure 4.4.1) is based on the four factors that The Findhorn Foundation uses for its sustainability model but, as David Christer explains, the spiritual factor is of greater importance as it reflects the personal motivation and affects the triple bottom line more than any of the other aspects (personal communication, September 21, 2007).

4.5 The Ideal Model

As mentioned, all four factors are interconnected, humans cannot prevail without an ethical-spiritual interaction with nature-environmental, and the model of economics has imbedded itself in our cultural or social structure.

To get a better understanding of how these structures–factors function, The Findhorn Foundation serves as a map for the success of potential future projects, bearing in mind that every setting is unique to its components.

- The **economic** factor is broken down into numerous fragments, each focusing on a demarcated area where the community develops small-scale businesses with a maximum diversity of produce. These small enterprises can be either cottage-based industries or craft orientated that can sell from home or flow into co-operatives that then supply their local shops. Consultancy – architecture or material choice specialists, accountancy – can also be a valuable tool to create an income through experience gained, or a skill developed in a particular sustainability field. Manufacturing for a local company could also be a source of income and could even stimulate a trade platform as a way of payment. Creating local services and proper education feeds back into the system, empowering everyone on all levels. Shares bought in community projects ensure self-investment. For example, the cow project in which a share costs £500 and an interest return of 5% a month is guaranteed. The method of payment of this interest is in either cheese or manure.
- The **environmental** factors mainly look at each home as a physical microcosm that needs to sustain itself but is considerably interlinked within the bigger structure, making it interdependent on the larger whole. The homes are laid out in such a manner that the natural elements are utilised to their fullest potential, and are well insulated to save heating energy, creating a unified design language but in different forms. The energy consumption focuses on renewable resources, 70% through their own wind energy farm, 20% on solar panels that collect heat for the water, and 10% wood that is collected from the local forest. The waste that is created in the community is recycled, all organic matter is returned to the soil via compost projects. The sewage is recycled through a "living machine" on the premises. All non-organics such as paper, metals and glass are collected by the municipal services that reprocess them into raw material.

The food that the community consumes is all organic, even that which is brought from abroad, although this is limited due to enlarging the carbon footprint. Seasonal consumption is a main issue and the green house is a functional tool to keep a natural balance.

- The **cultural** factors focus on people's need to be creative and express how they want to add knowledge, grow and diversify to create a stimulating and socially exciting place in which to live. The well being of the body and mind is translated into the term "people care" where support for each other, self-reliance and co-operation are key factors and are encouraged to ensure that people can progress, and in doing so can leave a legacy for future generations. Events such as dancing, singing, cooking, harvesting and building are mainly done on a communal basis, ensuring that there is a pollination of cultural events, performing and creative arts, skill development and job diversity, guaranteeing a bonding social momentum.
- The **spiritual** factor looks at the context of life and how it fits into a global scale, planetary dimensions, and how the Greater Reality influences it. The question of purpose within the bigger picture is explored by learning to live in harmony with nature and being in the present moment. The real interaction with what is happening is a reflection of our own divinity. The embracement of love and peace coincides with the term truth and enables a flow on to a platform of transformation that ensures expansion and transparency. The Findhorn Foundation is a strong believer that this is not based on a set religion, but is a personal choice that aids in creating a sustainable community (Findhorn Foundation 2007).

The challenge now is to inspire the government and educational institutions – our two main platforms – to aid in the change to a sustainability model; they are the backbone of our society and are not in tune with the crisis at hand. The current trend is about how to *work* and how that knowledge can be brought forward as opposed to how to *live* in the current society, and how we can build together, flowing into an emergent model (Sterling 2004:40).

There are at least a number of small individual groups that are tired of waiting for change; they might be the lighthouses – through either publicity or word of mouth – that may have a *trickle through* effect on the rest of society. Even through all the publicity that sustainability has been receiving in the last few years, it has been proved that if the leaders of a nation do not set the example or initiative, the rest of the country's inhabitants will not feel the urge to follow. The vastness of the problem may be the result of an insufficient vision or overview to resolve the challenge and it is easier just to set the problem aside (Sterling 2004:17).

When sustainability is looked at on a local scale, the question as to what is best for that specific place or area needs to be interrogated objectively and analysed with an open-mind (Braungart & McDonough 2002:124).

Current phosphate fertilisers are extracted from mined rocks. This is extremely destructive to the environment, whereas human waste (if not contaminated by discarded thinners, industrial wastes, cleaning chemicals and antibiotics) can be used to feed the soil with valuable phosphates as opposed to treating it as dumped waste (Braungart & McDonough 2002:102).

Ezio Manzini (2007) from the Unit of Research DIS-Design and Innovation for Sustainability INDACO in Politecnico di Milano, Italy gave a presentation at the DEFSA conference held in Cape Town on the 4th of October 2007 at CPUT. Manzini (2007) mentioned that as designers we could have developed the greenest cars on the road today, but if the mentality of the people does not change, the opportunity is missed. So often, people still travel alone in their vehicles causing even more congestion. We should stimulate the idea of people grouping together to eliminate the pollution and congestion problems.

The time for the statistical average is over; it is time to take action but it seems as if the passive bug has bitten everybody; it has numbed us all and we are dancing in a loop of bewilderment.

4.6 Summary

It is essential to make people aware of the consequences that result from the consumption patterns they have grown accustomed to in modern society. The responsibility lies within each of us to make conscious decisions regarding energy consumption and the impact our product has on the environment and how government and education play the leading role in altering the misconceptions at this level. The following chapter explores hemp as a product and how its sustainable values can be enhanced.

CHAPTER FIVE
PRODUCTS

5.1 Introduction

This chapter will explore the possible products, which can be derived from the hemp plant. The hemp plant can be separated into three main categories; the bast, the hurd and the seeds- different parts of the plant lend themselves to various application on account of their unique material properties.

5.2 Bast Fibre

In order to obtain the fibre that can be processed from the outer bast (Figure 5.2.1-A) there are a few ways to attain the desired sort of end product. The hemp first needs to go through the retting process to assist the separation of the bast from the hurd, and needs to dry until the moisture content is about 16% before it is transported to the processing plant. The separation or decortication (Figure 5.2.1-B) happens in a mechanical cutting, crushing, milling and separating process in rotating drums before it can be fed into the combing operation (Roulac 1997:179).

Figure 5.2.1: From hemp stalk to a processed product

(Vermeulen 2007)

The process of separation and combing is aided by jets of air blowing out the hurd through mesh, which can be repeated numerous times to remove the bast (Figure 5.2.1-C), depending on the desired application of the fibre. The colour difference between sample C and D in Figure 5.2.1 has to do with the retting period; the longer the process is applied, the darker the fibre turns. To soften the lignin in the bast fibres it can be heated from 160° C up to 260° C – the ideal temperature is 220°C – in an inert environment that causes the fibre to open up without affecting structural tissue and this makes it suitable for further processing (Bhuwan 2005:4271).

5.2.1 Textiles

The bast of the hemp plant is the source of fibre that does not require any complex machinery; it can be spun dry but becomes stronger and softer when it is processed wet. The spinning and weaving can be done as easily on the same looms as those used for jute and flax; small alterations need to be made due to the thicker thread that the fibre of hemp possesses (Carter 1907:106).

Hemp is such a durable fibre that it can be used either by itself or it blends very well with cotton, silk, bamboo, rayon or flax, resulting in garments that can be worn for decades, are absorbent, cool, and biodegradable. Hemp is a breathable natural fibre that is a good alternative to synthetic fibres based on petrochemicals. Up until the 1820s numerous products made from hemp were available in America, for example towels, quilts, bed sheets, rugs, drapes, tents, and clothing, and were readily available around the world far into the 20th century (Jamikorn & Wallner 2005).

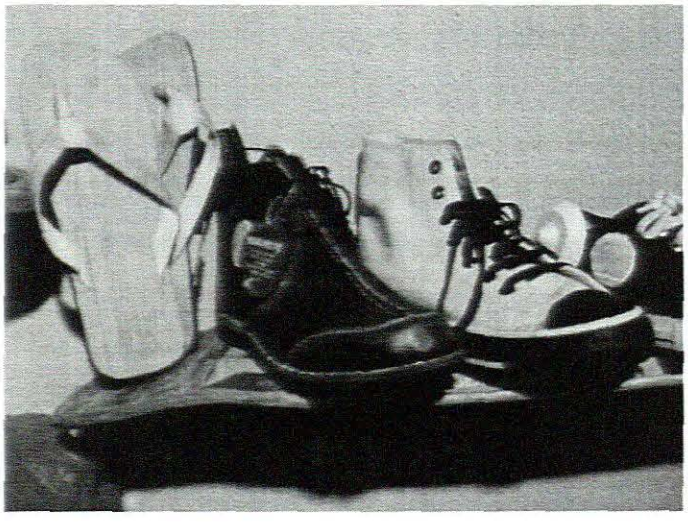


Figure 5.2.1.1: *Various upper parts of shoes made from hemp*

(Vermeulen 2007)

Hemp has a lustrous strong fibre that can withstand moisture, insects, and heat and has a natural ultra-violet (UV) resistance. Hemp is a durable fibre that was used for clothing suitable for all weather conditions and in Japan sailors even wore sandals manufactured completely from hemp (Paulhus 2004).

The porous characteristic of the fibre ensures a better bonding with dyes and the fibre can absorb up to 30% of its own weight in moisture without feeling wet (Dijkmeijer 1947:62), making it an ideal base for nappies or the American diaper. From an acre of full-grown hemp, about 25% to 50% of the plant can be turned into usable fibre, yielding an area of 500-1000 square meters of fabric that is spun to a number 10 thickness, which is similar to jeans material. A hundred thousand jeans can be manufactured from between 200 to 400 acres of hemp (Rosenthal 1994:71).

5.2.2 Rope

Hemp rope was slowly replaced by synthetic and steel cordage. However, in the old sailing ships, the rigging lines, made of hemp rope, would yield slightly, which was very favourable, as the forces on the contact point would be distributed better, thus preventing damage that could be caused by rigid steel cables (Conrad 1994:33).

Cordage, twine and rope have been produced using hemp as a source in 70-90% of most manufacturing cases up until 1937. For centuries hemp twine was incorporated as a carpet backing, which does not release toxic fumes after manufacturing in comparison with current synthetic products, which can also combust into volatile poisonous gasses in the case of home fires or in garbage dumps. In Japan, hemp was commonly used for straps on sandals (geta) or as packaging rope, and long-line fishing used for catching eels.

In archery the Japanese used rope made from hemp on their long bows (that were never seen in Asia or Europe), which could kill three men in line if the circumstances were ideal (Jamikorn & Wallner 2005). It seems that the rope was usually manufactured from the male plant, but a higher quality could be obtained from the female plant as the length of growth produced a stronger fibre that was slightly coarser but that could be ignored in the rope-turning process (Stoppelenburg 2006:14).

The process of making rope can be done manually; the machinery required is of little complexity whereas consistency is of great importance. After the bast has been removed from the hurd, the fibres are beaten – this step can be skipped as it weakens the fibre –

and combed over a board with an number of spikes to create a softer split fibre that is then ready to be spun (Stoppelenburg 2006:19).

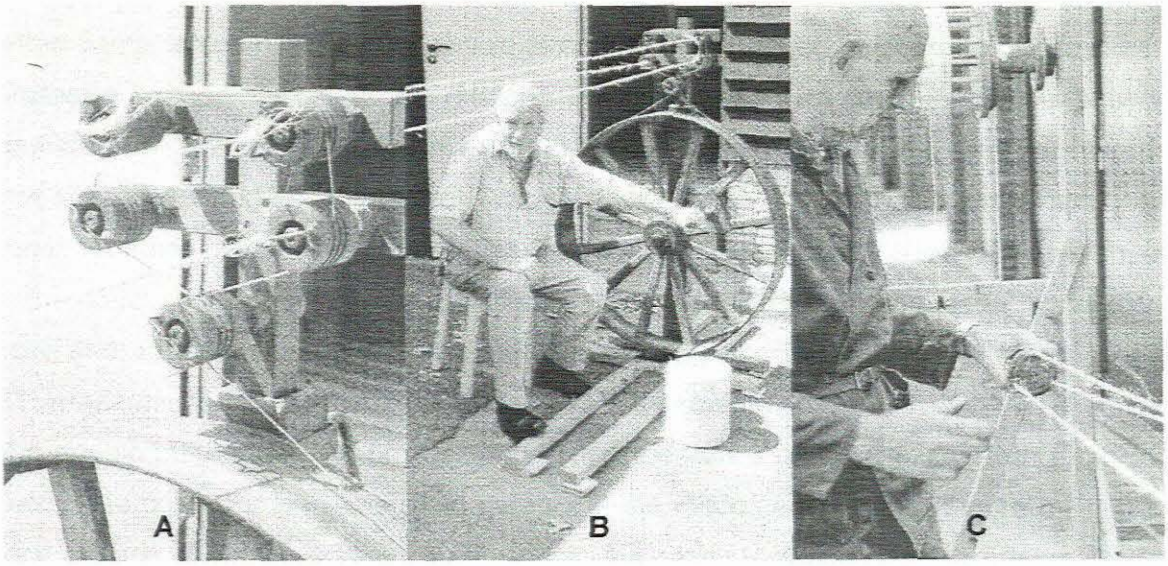


Figure 5.2.2.1: Equipment for rope spinning

(Stoppelenburg 2006:24)

The spinning is done by hand; a bundle of the fibres is placed around the waste, then tied to a spinning drum (Figure 5.2.2.1-A) and gradually fed towards the strand of yarn that is spun, while the wheel causing the rotational motion for twist in the twine can be hand operated also (Figure 5.2.2.1-B). After a strand is spun to a set length, three of them are spun into a bundle or rope using a wooden block (Figure 5.2.2.1-C) with slots to aid in the process (Stoppelenburg 2006:23). It proved to be helpful in the past when people did not have washing pegs but instead used the spin in the rope to clamp washing on the line and, through this pressure, even the with strongest gust of wind the laundry remained secure.

According to John Bold from **c.d. fox (pty.) ltd.** in Cape Town, there are no rope products available on the South African shelves besides some twine sold by the Hemporium, which supplies all sorts of rope. During a query regarding hemp rope, Bold mentions the irony of it; although it has always been illegal to grow the fibre, it was used by the Department of Justice for many years (until the death penalty was abolished) to knot nooses that were used to hang convicts sentenced to death (personal contact, 25 September 2007).

5.2.3 Reinforcement Fibre

Hemp in a polyester resin compound is often quoted as being one of the stiffest and strongest agro-fibres available (Sèbe 2000:342). Some of the best results are achieved with retted hemp, which has a higher tensile strength than un-retted hemp in a polyester matrix (Pallesen & Andersen 2002: 72). Natural Powered Speed Products (NPSP) is based in Haarlem, the Netherlands and manufactures composites (French for compile) materials that are transformed into items such as chairs, sculptures and high-end aerodynamic nose cones for trains (NPSP Compsieten, 2005). During a guided tour by Neils Harenbosch, one of the co-founders of NPSP, he explains how few industries have embraced this relatively easy and important process called the Vacuum Assisted Resin Transfer Moulding (VA-RTM) system, which has made numerous new experiments possible. The VA-RTM consists of a double mould that can be prepared or treated with a gel coat mixed with a pigment. Before the polyester is injected into the mould the reinforcement fibre (Figure 5-F), in this case a blend of hemp and flax, is placed into the cavity (personal communication, 21 May 2007). During the VA-RTM procedure a pump sucks out the air from the mould, creating a vacuum that ensures a filling to the outer corners or difficult to reach cavities while it is injected filled with a pre-mixed polyester thermosetting resin (Sèbe 2000:342). The VA-RTM technique enables a set standard to be obtained that incorporates a prerequisite surface texture and preset thicknesses, but also leaves space for abstract shapes of vast dimensions and complexity to be incorporated into the design (NPSP Compsieten, 2005).

Figure 5.2.3.1: Hemp reinforced road signs
(NPSP Compsieten, 2005)

This process has a technical application that has a relatively low investment and can reduce waste up to a maximum of 5%. The vapours can be contained and therefore a lower styrene emission is achieved, while a high-grade product is created that is mass produced easily.

The Dutch Automobile Association has chosen to go green with its new cycle road signage (Figure 5.2.3.1) and therefore has chosen hemp for a composite instead of a glass fibre blend. The advantage of this green hemp choice makes it possible to burn the signs when they need to be replaced 15 to 20 years down the line, compared to the old signs reinforced with glass fibre.

Speaker cones manufactured for Alcons Audio that were previously routed from blocks of wood are now being produced with a hemp/flax matting compound (NPSP Compsieten, 2005). After numerous tests and experimentation with glass fibre and hemp/flax reinforcement, resins proved that the natural fibres had the same sound characteristics as those of the wood counterpart. An encasing manufactured for a company involved in radar monitoring for traffic has used NPSP to experiment with new materials such as hemp reinforcement as opposed to glass fibre reinforcement. The company concluded that the hemp castings fragmented the radar signals much less than the old application (personal communication, 21 May 2007).

The current glass fibre signs create soot particles that will settle on the air scrubbers of modern power plants and thus make it more difficult to recycle the inherent energy of the waste product. It is not economically viable to recycle hemp or any other reinforcement fibre materials blended with polymers due to the chemical structures and bonding, as it requires technically advanced sorting processes. However, hemp does have a lower production energy footprint in comparison with the glass counterpart.

Between 1999 and 2000 the use of natural fibre in the German and Austrian automotive industry has increased by 19%, while in the same period the use of hemp had increased by 90%, making it rank second on the list of significant fibres for this future industry (Karus & Kaup 2002:120).

As the pressure increases to use more natural and plant-based fibres in reinforced polymer composites, factors such as regeneration, degradability, strength/weight ratio, and a reasonably low cost make the economic and intrinsic value become apparent (Sèbe 2000:342). With a demand of 25,000- 45,000 tonnes/year for hemp and flax fibres and an expected increase of about 500-3,000 tonnes/year for every new model developed, the economic savings are enormous due to the continually escalating cost of synthetic fibres that are directly related to the increasing oil price, not to mention the environmental impact.

On average about 5-10kg of fibre are used per vehicle and this excludes the upholstery. The impact of the hemp fibre can be seen in comparison with glass fibre reinforcement during a whole lifecycle – from the cultivation of the plant until the point of recycling/degradability – as a saving of 1.4kg CO_2 per kilogram of hemp can be achieved over its glass fibre counterpart (Karus & Kaup 2002:121).

Figure 5.2.3.2: Automotive natural fibre parts in SL series

(Small & Marcus 2002:303)

Some of the products (Figure 5.2.3.2) manufactured for the automotive industry include door panels, parcel trays, rear shelf panels, and column covers. These are made from hemp/flax fibres impregnated with poly-propylene and woven into mats, stacked in multi layers and then press-moulded under a high temperature, thus fusing it into the requisite forms known as thermoplasts (Karus & Kaup 2002:125).

Other factors that make the use of hemp/flax fibre attractive in reinforcement are the non-splintering/mechanical and acoustic properties, less wear on tools due to the softer processing requirements, and a large reduction in occupational health hazards when glass fibres are eliminated (Karus & Kaup 2002:122).

There is a huge debate between manufacturers and law makers regarding the recycling goals and actual feasibility at the *end-of-life* concerning compound products; automotive manufacturers suggest to rather burn the waste product for its inherent energy as opposed to investing three time the energy in order to recycle it (Ashby & Johnson 2005:230). At a conference held in Germany in November 2006 by the European Industrial Hemp Association (EIHA), Canadians shared the enthusiasm of the new development in a blend of hemp fibres and Polylactide (Carus 2006:1).

5.2.4 Insulation Mats

The process of the manufacturing insulation mats starts with the fibre that is combed into a fluffy fleece of about 40-50mm in thickness. It is sprayed with water glass and dried in a hot air tunnel at about 150°C. The fleece is then turned over and treated with water glass and rolled through a pressure roller to a calibrated thickness of 12mm. For the requisite thickness, between four and 12 fleece mats are bonded together by means of the glass water and again rolled, after which they are dried once more at a temperature of 120°C and then cut to size (Grohe 2004:353).

A thermoplastic can also be used as a binder and the fleece can be treated with inorganic salts to ensure a fire-delaying action and create a resistance to pests (Natural Deco 2007). *When hemp fibres are matted into insulation rolls (Figure 5.2.1-E+G), the insulating factor* of λ0,040 W/m.K can be attained with a raw density of 25kg/m^3 and a primary energy content of about 30kWh/m^3 (Schmitz-Günther 1998:223).

The advantage of using natural fibre in the manufacture of the insulation mats is that it requires no protective clothing during installation into new or existing building, as it will not irritate the skin, eyes and respiratory system. It is advisable to wear a dust mask when it is installed in old dusty areas. As opposed to glass fibres that do not absorb or retain moisture, natural fibres do and can even release the dampness to maintain levels of comfortable moisture and humidity, which are beneficial for healthy and agreeable surroundings. The benefits of these "hygrothermal properties" (Ecomerchant 2007) will only be obtained if the structure can breathe properly or vapour-penetrable barriers are in place.

The matting can be of such a sturdy composition that it becomes a supportive core structure in mattresses. The core can then be covered with latex foam and an outer hemp fabric to create a 100% naturally-based product (Schmitz-Günther 1998:420).

5.2.5 Paper

Some of the advantages of hemp paper that stand out over other paper products are a better opacity, it endures excessive folding, has a high tensile and wet strength, and is tear resistant. A hemp-based piece of paper can be recycled seven times, compared to three times for its wood counterpart, without compromising the surface and substrate that is required for modern day printing (Guy 2004).

The fibres sourced from the hemp plant can be used for the production of paper, card or board starting with the long bast fibre and its shorter secondary fibre. The hemp plant's shortest hurd fibre can be blended with the pulp of recycled paper because its additional long and strong fibre characteristics extend the potential reuse of paper even further (Conrad 1994:115).

Hemp bast fibre enhances the strength quality of paper and is an ideal supplement for wood-based pulp, which is currently mixed with other organically grown crops such as cotton, flax or even wheat straw to achieve a stipulated surface, opacity and weight. Hemp is a good non-wood fibre for cigarette paper; currency paper and filter paper is even used in the teabag industry, creating a viable ecologically-friendly product. The blending processes are still in the experimental/research stage, resulting in an initial high cost, but producers are willing to pay for a higher quality and, as products are developed, the cost may drop considerably (Industrial Hemp in the United States 2006:13).

In contrast to tree-based paper where great amounts of chlorine are used to extract the lignin content that then converts into dioxins and other pollutants such as sulphur-based acids, bleaching is used. Paper made from hemp has a low level of lignin that can be dissolved with a nature-friendly chlorine or hydrogen peroxide, resulting in less contaminated residue returning into the water cycle (Boy 1994). With hemp pulp yields of up to four times that of its wood counterpart per hectare, the final paper product also does not become brittle, decompose or yellow, thus ensuring that the paper manufactured from hemp will outlive humans by hundreds of years. On the other hand, wood-based paper lasts about 50 years (Roulac 1997:120).

5.2.6 Weaving

The South African culture is familiar with weaving intricate shapes and patterns that can be produced easily from hemp bast. If the bast were to be removed manually, the full circumference of the plant could be obtained (Figure 5.2.6.1- A) and split according to the width required to then produce products such as baskets, lids (Figure 5.2.6.1- B) and bowls (Paulhus 2004).

Figure 5.2.6.1: Bast fibre

(Vermeulen 2007)

5.3 Hurd

The hurd has numerous uses in the industry, but at this stage it is mainly used as bedding for horses in Dutch stables due to its superior absorption rate. Frans Thielen from the company Aubiose explains that due to a shortage of wood shavings, a vast number of horse stables have chosen this eco resolution. The company is based in Tilburg, the Netherlands and focuses mainly on importing hemp hurd from France.

Figure 5.3.1: Bedding for animals

(Vermeulen 2007)

Thielen also maintains that the hemp product is far superior to its wood counterpart; it *creates less dust than conventional bedding and is much better for horses that suffer from* hay fever (personal communication, 29 June 2007). The hurd product can be obtained in various bale sizes ranging from 2kg to 15kg (Figure 5.3.1). Through personal experimentation, I have determined that hemp can absorb up to 5 times its own weight in water.

5.3.1 Insulation

Besides the insulation mats that have been described earlier, hemp can be sprayed into cavities of cellulose material – finely chopped up hemp hurd – creating a seamless insulation that has an amazing insulating factor of λ0,040W/m.K, a raw density of 35kg/m^3, and a primary energy content of about 50kWh/m^3 (Schmitz-Günther 1998:223). It is advisable to wear respiratory and eye protection while spraying the cellulose into the cavities between floors or in walls of new and renovated structures, as dust that has collected through time will be disturbed.

5.3.2 Particleboard

A relatively inexpensive board can be made by heating up hurd and compressing it together with additives to produce a fire-resistant material that also has excellent sound-insulating and thermal qualities suitable for construction purposes. This superior board can be used to replace dry walls and plywood manufactured from wood-based materials (Jamikorn & Wallner 2005).

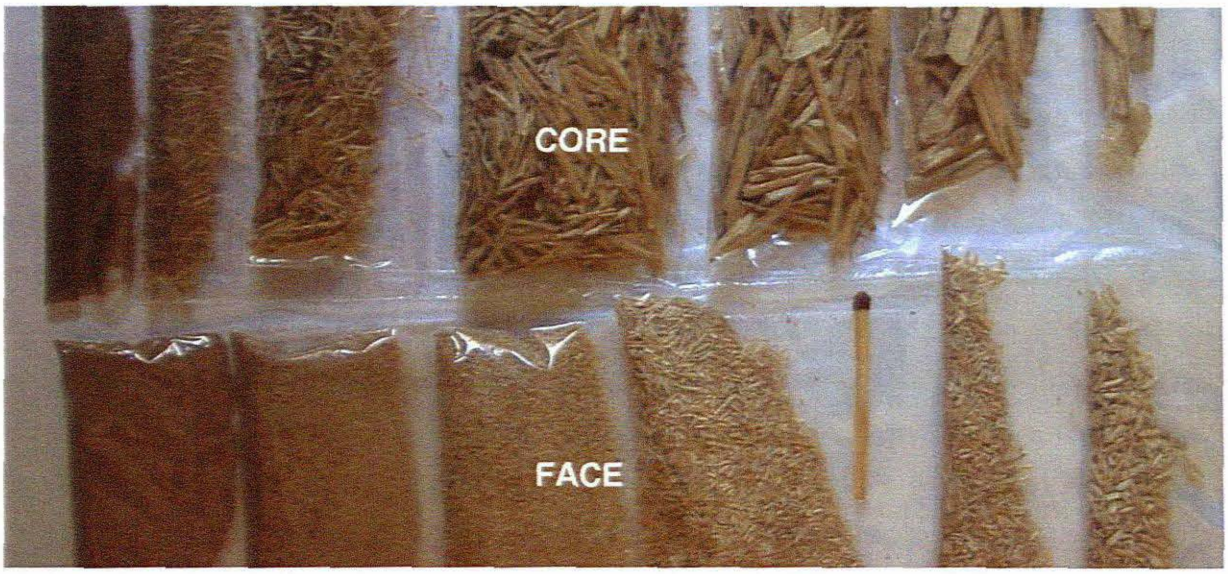


Figure 5.3.2.1: Wood chip sizes for particleboard

(Vermeulen 2007)

George McDonald of the P.G. Bison plant in Stellenbosch, where wood-based particleboards are manufactured, explains that boards with a thickness of 16mm roll out on a daily basis (personal communication, 12 September 2007).

The board consists of a core that is imbedded between a face on either side, each having a different density. The wood chips shown in the samples are for the core and face, which vary in size but may not exceed set standards and volume percentage in the production line, as they will absorb either too much glue, create a rough face surface, or weaken the structural strength (Figure 5.3.2.1).

The wood chips are mixed (atomised) with urea formaldehyde; a chlorine-based glue that is very toxic for the environment. It also depends on the moisture content to set during the pressing period in the heated hydraulic press. The moisture of the wood chips ranges from 2,5% for the core with a glue content of 6,8%, while a glue content of 7,8% is required for the face with a moisture content of 14 to 16%. The moisture or water in the chips is a calculated heat transfer agent in the oil-heated moulds set at 100°C.
The sides of the particleboard are left open to guarantee an available surface area through which the moisture can escape. A cycle time of 200 seconds produces four boards, which are stacked on top of one another with heat moulds placed between each board and will yield a daily production of 250m³ of particleboard (personal communication, 21 May 2007).

The hemp hurd can be processed on a conventional wood fibreboard production line without any alterations, ensuring that there are no additional start-up costs. Due to its inconsistent supply a multi-national company such as P. G. Bison will not consider it.

Hurds are chopped into lengths of 25mm or shorter, without compromising their strength, to prevent jamming of the existing wood mills (van Wyk 2000:300). Straw can be blended with hemp hurd to compensate for currently scarce hemp resources without reducing the quality of the comparable wood-type board. This is because 100% hemp board is two and a half times stronger than the current wood medium-density fibreboard (MDF) composite. There have been cases where modern industrial applications have proved that the un-retted hemp plants can be applied without separating the hurd from the bast for the manufacture of MDF (Roulac 1997:159). The hemp particleboard has an elasticity factor three times higher than the wood-based MDF, which makes it easy for nails to penetrate it (Osburn & Osburn 1994). There is great potential for creating structural building materials such as beams and posts out of the compressed hemp hurd with the same strength of steel to become the future competitor for I-beams (Boy 1994).

Compared to concrete, hemp has the same strength factor yet is biodegradable, much lighter, is as fire-resistant as a board, and it can bend and curve easily (Hemp info 2006).

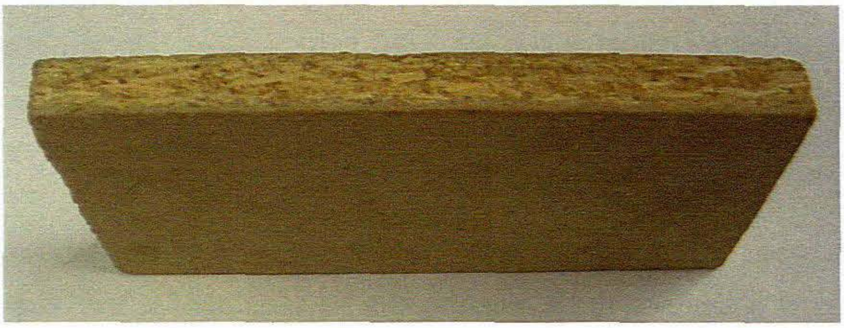


Figure 5.3.2.2: Hemp particleboard

(Vermeulen 2007)

The main issue that has to be highlighted is the choice of the adhesive that will be used for the manufacture of the particleboard. This is because the urea formaldehyde can be replaced with a product called *AEL* that is still manufactured from a petrochemical based source, but has no toxic characteristics. In an interview with Douglas Jenman of Adeguate Energy, I learned that the choice lies mainly in the cost of the glues; the urea formaldehyde costs R3,500 per ton in contrast to *AEL* that is R9,000 per ton, but is not harmful to the environment when recycled (personal communication, 13 September 2007).

5.3.3 Plastics

The hemp plant has numerous characteristics that can transform into an ideal base for biodegradable products with highly antibacterial qualities, and in addition has no harmful by-products. Just like any petrochemical-based plastic, it can be moulded into almost any imaginable shape, but has a negligible impact on the environment due to the ecological and environmental waste repercussions (Hemp info 2006).

The plastics that can be derived from hemp may be processed in various ways; the hurds make excellent cellophane that was commonly used up to 1930, but even today it is still part of a plant-based packaging material (Roulac 1997:120). A process called esterification mixes the high cellulose content hurd with acid to create a resin that can have an optical transparency of up to 90%. The cellophane can be modified for outdoor use (Ashby & Johnson 2005:198) and can result in plastic plumbing pipes currently made from polyvinyl chloride (PVC), ensuring that the currently used non-renewable, chemical petroleum-based or coal feedstock can be eliminated in the manufacturing process (Jamikorn & Wallner 2005).

Hemp is a suitable filler where a mixture ratio of 50% hemp hurds to 50% recycled plastics is used for the production of injection-moulded parts. The oil obtained from pressing the seed can be "converted into a valuable plastic resin" (Guy 2004:1).

The concept of spraying plastics on to or into moulds was described in the article *Shelters of Sprayed Plastic* in the Popular Mechanics Magazine (1957:105). It explains how a tubular frame was covered with a cloth tape at 15cm intervals and then covered by spraying it with a quick-setting plastic.

Zelfo is an Australian-based company that has devised a technique to blend high cellulose material and water that is then sprayed into pre-manufactured moulds to acquire a new product called *hempstone* when manufactured from hemp. A blend of 15% hurd and 85% water is pulverised and is then heated for a set time. Pigments and other additives can be used to complete the brew/pulp, which then is sprayed into the mould. As Paul Benhaim explains during a telephonic interview, the moulds are mainly made from concrete due to the water absorption rate and life expectancy; they last for extended periods. The company manufactures any shape, whether it is hollow or cylindrical, but cubed objects of about 1.5m are ideal. It is possible to run a small batch of about 20 to make the process profitable. Benhaim explains that, "We can do up to 2,000 high-end designs if they were to be ordered." The finished product is rock hard, does not chip and can be sanded, polished and then varnished or painted just like any other wood product. Polystyrene blocks are cut into any desired shape, for example a chair and then covered with the hempstone to create a protective layer that looks and feels like wood. The production plant runs on natural resources such as solar energy, the burning of hemp waste, and all the water is recycled (personal communication, 20 October 2006).

5.3.4 Building Material

Wheat and barley bale homes have been built for some years now, but there seems to be a problem with dampness that is collected by the straw. This situation does not seem to occur with hemp, and it therefore becomes a viable replacement. Another positive point is the tougher and longer lasting characteristics of the hemp in comparison to the wheat bales.

A slight disadvantage is that hemp bales are quite demanding to work with as their toughness makes them difficult to pin down. This tends to increase the labour required to build a structure. However, hand- or -machine-chopped hemp hurd is mixed with lime or earth and this allows it to be cast into wall structures and moulds, the size of bricks. Chopped hemp hurds of about 2,5cm in length can be used for the casting process but longer lengths do not seem to raise any problems with the casting method, as they seem to offer an additional strength (Kennedy 2002:161).

For flooring, a mixture of broken glass and lime (to repel rodents) can be used to start a base on to which a layer of pebbles with a diameter ranging from 20 to100mm is placed. This necessary step ensures air circulation to prevent capillary water movement prior to a layer of hempcrete being cast over it. The hempcrete used in floors consists of 10 volume parts hurd, three volume parts lime/ binder mixture, and four volume parts water.

A *lime/binder mix consisting of a hydrated lime (seven volume parts)*, hydraulic lime (1.5 volume parts), and cement (1.5 volume parts) is used for spraying the surface. This guarantees an immediate set, but in dry warm climates or when applied by hand this should be avoided as it sets too quickly (Allin 2005:146).

In France a company developed a lime mix called Iso-Chanvre (chanvre is the French word for hemp). It is based on a recipe derived from samples taken from a bridge in the south of France that was built during the Merovingian period; it is a mixture of lime and hemp hurd. *Archaeologists found that this combination of lime and hemp petrifies into a mineral state* that has lasted for centuries (Jamikorn & Wallner 2005).

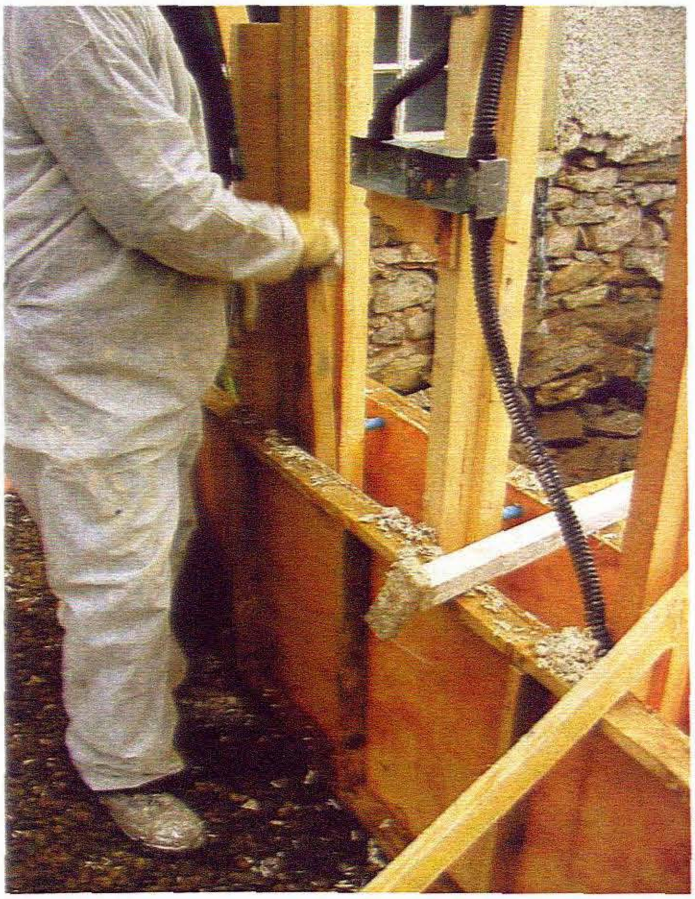


Figure 5.3.4.1: Compressing a hemp mixture into a wall mould

(Allin 2005:130)

The hemp and lime mixture can also be used in conjunction with wooden frame structures (Figure 5.3.4.1) or as freestanding walls, and because the hemp requires small amounts of water when mixed with hydraulic lime (as it binds very well) the mould can be removed almost immediately after casting. The walls can be built with a thickness of about 20cm with casting lifts of between 75 and 90cm in height (Kennedy 2002:162).
The mixing ratio for such a wall cast is 10 volume parts hurd, 2.5 volume parts lime mix, and four volume parts water (Allin 2005:146).

The drying period of the hemp/lime mixture is about two to three weeks depending on the surrounding humidity. However, it remains relatively waterproof. To ensure proper protection, the outer and inner walls can be finished with a lime plaster, but when a thicker plaster is required, it can be mixed with 10 volume parts hemp, nine volume parts lime mixture, and five to six volume parts water (Allin 2005:147).

The lime/hemp mixture does not shrink and is dimensionally stable and it can absorb a high degree of water vapour, while at the same time it remains feeling warm and dry to the touch. The walls manufactured from the hemp/lime mixture have the ability to breath. Thus, they adjust the humidity and the temperature of a home and create a comfortable atmosphere. This results in a cool interior during summer and a warm space in winter; consequently, it reduces both cooling and heating costs (Hemp info 2006). Due to the lime that coats the hurd, it is rendered non-combustible and therefore eliminates fires in normal houses; the hurd merely smoulders in the lime and does not ignite (Allin 2005:59).

The building blocks that are cast in thicknesses of 20cm and bonded together with a lime mortar as an alternative to casting walls do not have the same shear strength. The consequence is a weaker structure (Kennedy 2002:162). The blocks should be cast at least one or two months before handling to ensure proper curing but, since the moisture content is higher than 70%, greater caution is required when they are moved. The hurd with some fibre can also be cast into ceiling panels; due to the reinforcement characteristics of the fibre a minimum thickness of 50mm can be obtained. The fibre content should not exceed 15% of the hurd's volume, as it holds moisture for longer periods and can also create lumps when with it is being mixed with lime (Allin 2005:74). With the proper moulds and some imagination the hempcrete and fibre mixture can be transformed into some complex shapes; the main restriction is the designer's imagination (Allin 2005:74).

5.3.5 Thatching

Other alternative applications of hemp in the building industry are unretted stalks used as roof thatching in Japan on Shinto temples (Miasa village 2006), which have lasted for centuries. To investigate the feasibility of introducing hemp stalks on the local market, a perusal of the guidelines set by the South Africa Thatching Association could point one in the right direction. The grass that is used should not have a moisture content greater than 15%, which is similar to the harvesting criteria set for hemp. The grass should be straight, yellow in colour, have a minimum length of 90cm, and be stripped of leaves and seeds (Highveld Cape Thatchers 2002).

The thatching is laid out with a minimum thickness of 175mm and bound down on to the roof frame with sisal; this too could be replaced with hemp. As Michael Howard from Thatchsayf explains, a special coating was developed that is sprayed on to the grass and Cape reed thatching to create a fire-retardant layer to the roofing, which will delay the ignition of the roofing.

After mentioning the idea of replacing the current product with hemp, Howard suggests having a sample sent to their branch in Johannesburg to conduct some tests. The main concern regarding hemp is whether the oil content in the stalk is too high. This would defeat the purpose of treating hemp with the fireproofing chemical, as it will only delay the point of ignition for a brief time. Samples have been sent to Thatchsayf's laboratory to determine the flashpoint and oil content of the hemp stalks and I am still awaiting the results.

5.4 Seeds

It is possible to reach a maximum of 82kg/ha seed crop with hemp strands especially cultivated for their seed production. Each seed has an oil content of 30-40% (Rosenthal 1994:141).

5.4.1 Oil

Hemp seeds can be used for soap, as well as for food preparations such as margarine (Rosenthal 1994:141). The base for paints and varnishes that were manufactured for thousands of years was usually a hemp-linseed oil, or a blend of the two, which ensured deep penetration (due to its low viscosity) into the wood fibre and also preserved it extremely well. Products like solvents, printing inks, putty, and chain saw lubricants can be derived from the oil (Roulac 1997:15).

As a fuel for oil lamps, hemp was used extensively until about 1800, when it had to make way for the even cleaner-burning whale oil. The latter was in existence until the 1870s in America and the rest of the world (Jamikorn & Wallner 2005).

The oil pressed from the hemp seed is rich in polyunsaturated essential fatty acids (EFA's) and can easily be absorbed by lipids damaged by the sun. This renders it ideal for replenishing skin cells (Rosenthal 1994:176). The Body Shop has numerous as hand-, body-, foot-, face-, and lip-care products (Figure 5.4.1.1) that have traces of hemp oil processed into them. Personal experience of the product's moisturising ability has been satisfactory.

During an experiment with the chopped up hurd at home, my housemate mentioned that the texture reminded her of face scrub granules and when investigated further it could very well be a candidate for this application.

Figure 5.4.1.1: Body Shop hemp products

(Vermeulen 2007)

When processed in the same way as crude oil, hemp seeds have the ability to be transformed into a fuel with the same ignition qualities as diesel fuel. The high cellulose content of the stem can also be turned into a biomass methanol or ethanol product free of any heavy metals or sulphurs that can pollute the environment (Hemp info 2006).

Even though it has been suggested that hemp should be cultivated in North American on 6% of its arable land to meet the country's fuel requirement (at a wholesale price of $0.60

per gallon), an astounding $40-$100 can be fetched for a gallon of hemp oil when it is sold to the cosmetic or food industry (Rosenthal 1994:142).

Numerous tests have been carried out to prove to the world that it is possible to drive long distances using hemp oil as fuel. For example, there is the case of a vehicle that left Takigawa City, Northern Hokkaido, Japan on the 29th of April 2002 and covered 12,500km using 2,600 litres of fuel. The journey ended on the 11th of September 2002 (Hemp info 2006).

5.4.2 Food

The seeds of the hemp plant can be cold pressed to produce oil with a nutty flavour and a gold or green colour. This may be used instead of olive oil, butter or walnut oil in dressings for salads, sautéing meats, or stir frying vegetables. Hemp does not lend itself to deep frying as it starts smoking at a low temperature, thus indicating that there is polymerisation and unhealthy anti oxidants accumulating (Pless & Leson 1998:4).

Figure 5.4.2.1: A variety of hemp food products

(Vermeulen 2007)

Hemp seeds are one of the few nuts that have a very low level of "polyunsaturated fatty acids (Callaway 2004:65)". The essential fatty acids (EFA) that are so important for one's immune system may measure up to 80% of the seeds' nutritional content.

Besides the EFA, there are proteins in the seeds that can aid in the relief of symptom for diseases such as HIV/AIDS and Parkinson's, as well as having a positive effect on arteriosclerosis and Alzheimer's. The albumin (a protein generally produced by the liver) present in the seed can help with patients suffering from liver and kidney disorders and the glutamic acid (a neurotransmitter) contained in the seed in large quantities is help in alleviation of stress- related symptoms (Hemp Research 2008).

The build up of the EFA oil in a hemp seed consists of 55% linoleic acid (LA), also known as 18:2 omega-6 and 5% linolenic acid (LNA), and up to 25% of alpha-linolenic acid (ALA), also known as 18:3 omega-3 after pressing (Jamikorn & Wallner 2005).

Besides the EFAs, there are some traces of polyunsaturated fatty acids (Tocopherols or Vitamin E) that seldom occur in seeds, but are valuable nutrients found in hemp seeds. For a daily balance of EFAs there should be ratio of three parts linoleic acid to two parts alpha-linolenic acid; hemp oil is the only natural oil that comes close to this proportion to meet our daily requirement of EFAs (Pless & Leson 1998:5).

The residue cake that is derived from the pressed hemp seeds is a high quality food for livestock, but it can also be turned into products such as spaghetti (Figure 5.4.2.1), pasta or pancake mix. Aroma essence extracted from the hemp plant is also used to flavour energy drinks or beer brewed in Germany. According to Melvin Moodien, birds are fond of hemp and mixed in at a ration of 2% of other seeds that can be found on pet store shelves in a blend called Amazon Parrot produced by Avi-Products (PTY) Ltd based in KwaZulu-Natal (personal communication, 2 November 2007).

5.5 Summary

Hemp has been acknowledged by numerous companies as a replacement for conventional materials such as plastics from petro-chemical, synthetic fibres, products and other materials. Advances in technology enable the processing of the hemp fibres, whilst experimentation allows for familiar applications that have a more positive impact on the environment than the current competitors. To understand what impact hemp might have on the environment, a comparison will be made with other existing materials in the following chapter.

CHAPTER SIX
LIFE CYCLE ANALYSIS

6.1 Introduction

To gain better insight into how a completed product can impact upon the environment, a Life Cycle Analysis (LCA) can be conducted to give an indication of what is involved in the manufacturing process as well as pre- and post-production of the articles' life.

6.2 Need for LCA

Currently in most cases where raw materials are used to develop a new product, the lifespan versus material growth span has to be considered carefully. Frequently, the materials used to manufacture a wooden bookshelf take longer to grow than the actual period of the object's usefulness after its manufacturing stage (Boy 1994). The importance of re-assessing the value of the product in its entire lifespan can make the level of awareness amongst consumers and manufacturers shift to a new cooperation, thereby *sharing a human scale of understanding of the benefits of waste reduction* (Sterling 2004:13).

Consequently, when a raw material is prescribed for a manufacturing process, its impact (or carbon footprint) on the environment should be carefully evaluated before the final selection is made; the easiest option may not be the best outcome-based source. This raises the question of how our present choices will reflect on the future outcomes, resulting in a "feedforward" analysis (Braungart & McDonough 2002:145).

6.2.1 LCA Evaluation

In Bremen, Germany at the University of Applied Sciences, a LCA was compiled using a component for a bus to determine the feasibility of natural fibres in future products. To get a *better understanding of the impact materials have on the environment, a comparison was* made between a traditionally used polyester resin with glass fibre and hemp fibres blended with PTP™ (Schmehl et al. 2007:1).

The whole life-cycle of the source materials (whether agricultural or manufactured), the production and the disposable cycle were all analysed and assessed. All components in the processing chain that were similar for both material applications were factored out to focus on the important differences. Some of the similar points were, finishing, mounting, transport and disassembly (Schmehl et al. 2007:2).

The ECO-indicator 99 Points was used as it has a broad impact scale to calculate the required outcome for this assessment being able to view components such as ecosystems, health and resources. The energy consumption that is displayed in Figure 6.2.1.1indicates the total amount that was used for the primary production that was absorbed by the part. The bus part hat was manufactured from eco-materials displayed at least 50% reduction in negative impact on numerous levels (Schmehl et al. 2007:4).

The main factor that plays the largest role in the GF-UP is the required fossil fuel needed to produce the resins and the glass fibre, the high carcinogenic levels in the NFK I and NFK Opt. are due to the packaging materials needed for the curing stage of the PTP resins but further research can reduce this level to a minimum (Schmehl et al. 2007:4).

Due to the lack of hemp production in South Africa, it is very difficult to determine what the LCA values will be for this country. Models that have been studied abroad could be used to indicate what the values could be if they are applied in South Africa.

In Table 6.2.1.2 a comparison is drawn between cotton and hemp, the values are derived from the energy necessary to grow and harvest a crop and also indicate what greenhouse emissions are created during the process.

Table 6.2.1.2: *Energy consumption and greenhouse discharge for cotton and hemp* (Roulac 1997:170)

Crop 1 metric ton	PE GJ	CO_2 kg	NO_2 kg	CO_2-Eq Kg	SO_2 kg	NO_2 kg	CO_2-Eq Kg
Cotton	25.2	1,680	3.0	2,650	2.5	14.8	12.9
Hemp	8.2	544	1.3	947	1.2	4.5	4.4

1.Primary energy consumption; 2.CO_2-Equivalent, measure for global greenhouse potential
3.SO_2- Equivalent, measure for total acidification.

Hemp can alleviate the dependence of small communities on the monopoly of large corporations regarding the supply of energy, since it can be turned into a sustainable biomass fuel that burns cleaner, creating a better economy and ecology (Jamikorn & Wallner 2005). The hemp plant's rapid growth rate can create a stable supply of seeds when locally grown, as well as achieve self-sustaining viability within a year or two in a small-scale industry, and in about five to 10 years for large-scale farming (Rosenthal 1994:293).

6.3 The Carbon Alleviation Program

Thierry Revert of South African Council for Organic Development and Sustainability (SACODAS) explains that the situation in South Africa is unique, as it supplies the world market with carbon credits. When green projects are developed and maintained, the credits created can be sold to countries requiring them and, in doing so, create more investment capital returning to South Africa for further development of the local market. One of the fields that would benefit from this approach is the housing industry, as there is a shortage of low-income social housing. This would be beneficial especially if they were constructed from a hemp and lime blend (personal communication, 9 October 2007).

As a reference example, the United Kingdom produces almost 50% of its annual CO_2 *output through the building industry, as well as maintaining the installed utilities such as* heating and cooling (Building Lime innovation 2007:8).

The Reconstruction and Development Programme (RDP) focusing on social low-income homes have a surface area of $40m^2$. To build a home of $48m^2$ with walls 300mm thick it *would require* $33m^3$ *of a lime/hemp mixture. This would translate into 165 bales of hurd and* 7.25 ton of lime blend.

The amount of hurd that can be produced from a hemp stalk is approximately 60% and when compressed into a bale, will contain 200 litres of uncompressed material. There are about 50 bales of hurd in one ton; a hectare of land will produce between five to six tons of hurd. Thus, on one hectare there will be between 250-300 bales of hurd that can be used to build almost two homes (Building Lime innovation 2007:22).

As hemp grows, it converts absorbed CO_2 into cellulose, glucose, lignin and hemi-cellulose. During this process the CO_2 is split into a carbon molecule, which is linked to the structure of the plant, while the oxygen is freed and returned to the atmosphere. On average, 1.84 tonnes of CO_2 is used to produce a ton of dry hemp, ensuring that the lime mixture traps 330kg of CO_2 per tonne. CO_2 is also emitted during the production process and, on an average $48m^2$-house, 3.6 tonne of CO_2 will be embedded in the walls (Building Lime innovation 2007:8). Current conventional materials, which are used for the construction of homes lead to CO_2 outputs in the tens-of-tons figures. If there were a conscious choice to include hemp and lime mixtures into the building industry, 50 tons of CO_2 can be saved per home (Building Lime innovation 2007:8).

If a hemp/lime structure was to be removed, it could be ground up and returned to nature where it can boost the ph value of the soil or become compost-able mulch. The negative side to this process is that the locked up CO_2 value will be released back into the environment as the decomposition takes place (Building Lime innovation 2007:8).

6.4 Rules for a Sustainable Product

Luttropp and Lagerstedt developed a set of guidelines in 2005 that consisted of ten golden rules essential when designing a new product; this was published in 2006. It is very challenging to follow these prescribed criteria, as they require a new way of thinking on all levels of product design. The job of the designer has passed the stage of just coming up with a pretty shape for an object; the time has come for manufacturers to take greater *responsibility for the further well-being of the planet and all its inhabitants.* These ten golden rules will be applied to hemp as a resource to replace different materials as opposed to a particular product.

1. *Does the product require any toxic substances during production?*

It has been proved that hemp does not require any pesticides due to its natural resistance to insects. Weed sprays are also not necessary during crop growth as the hemp plants smother any invaders, reducing the use of chemicals even more during the growth phase. Fertilisers are not required for the production of hemp but can aid in the growth process to enhance the yield. The use of effluent can alleviate fertiliser application to some degree, due to the high mineral content in the fluid supplied by the local wastewater plant.

2. *Minimise the use of energy in the production and transport phases*

If the area for planting is chosen correctly, a natural downpour will be sufficient to water the crop and alleviate the energy that is required to irrigate it with sprinkler systems. The harvesting of hemp can be done either manually or with machines. The latter do consume a fossil fuel, so the choice of powering them with bio-fuel is obviously a cleaner option. The retting is the most energy intensive factor of harvesting, as the crop needs to be turned over at least twice before it is ready for processing. This action can be accomplished manually or another option is to add an enzyme to the hemp to speed up the retting process.

Even though hemp is light, it is a bulky crop and requires large volume transport. It is possible to decorticate hemp on the field to ensure that the bast and fibre travel directly to their processing destination without creating any unnecessary detours.

3. *Replace materials based on their superior strengths and weight*

Hemp is a strong candidate to replace the cotton that is currently dominating the natural fibre market. Hemp is more durable, ensuring that garments will last up to five times longer if they are not driven by fashion. In the automotive industry, hemp is replacing plastics as it is a more suitable product for heat and sound insulation. It is a competitive contender for reinforcing composites as opposed to the current glass fibre usage and, even though it is slightly less rugged, it demands less energy to produce the product. In the paper industry, hemp can play a major role in supplanting conventional wood-pulp-based products, as its fibres are longer and stronger. This allows for several extra salvage cycles over the current products used.

4. *Promote upgrading and repair possibilities*

Education can play a main key in this area, as it is important to make consumers aware of what effects their lifestyles have on the environment and how we all have a role to play in this stage of our consumption patterns. A positive attitude towards one another, respecting nature, plus investing time in an open dialogue between consumer and producer can result in an almost personalised range of consumables, and in doing so generate an upward motion; a will to improve. Through this awareness, a new sense of care can arise and result in the restoration of nature's quickly diminishing diversity of clean resources such as soil, water, and air. Hemp can aid in the healing or upgrading of nature through properties such as stabilizing soil or purifying it, but is also an ideal replacement for harmful materials such as glass-fibre too.

5. *Minimise energy in the resource and usage phases*

Panels installed into motor vehicles can reduce their body weight substantially. The result is lower fuel consumption during the product's use, thus adding to some of the energy savings that can be achieved. The machines that are utilised for the production of linen can also be installed for manufacturing hemp textiles, with only minor alterations being necessary. This means that the same machines can be employed further without having to reinvest in specialised equipment.

6. *Promote a longer product life*

In the case of fabrics, hemp has a natural UV resistance, prolonging the fabric's life and ensuring that fewer additives are used to stabilise synthetically produced materials for awnings and garden furniture. Canvas fabricated from hemp is also mould resistant, making it a suitable possibility for outside applications. The focus should be placed on products that people would want to have for longer periods and, if a trend aspect of "green design" could be perceived as stylish, products would actually last longer. The attitude of obsolescence should be re-assessed and replaced with the desire to design products that users want to have for a lifetime; they would also grow in character and gather memories as time passes.

7. *Prearrange upgrading and recycling*

Government should promote programs that guide and motivate the people to become involved actively in recycling and forward thinking. This could spark off new innovative ideas that people can then feed back into the system to promote dynamic enhancement in small communities, as well as a sense of pride and growth. Hemp can play a role in this approach, but it is essential to balance the diversity of food growth and water management in relationship to natural energy resources. If applied properly, hemp can be recycled back into the natural cycle if it is not contaminated with chemical binders and resins.

8. *Ensure reduced maintenance*

Glass fibres are harder than their hemp counterpart is, and entail a higher level of wear and tear on machines that process them. If replaced with softer, friendlier fibres, a reduction in healthcare can also be achieved, as hemp has fewer irritating effects on the body than glass fibre. When manufacturers phase out the heavier plastics in vehicles, the weight of cars would be reduced substantially. In consequence, there would be less degradation of the mechanical parts and the life of the vehicle would be prolonged.

9. *Avoid blends that complicate recycling*

In the case of particleboard, it is important to choose the correct binder. It is essential that the discarded product can be returned to the soil free of any chemicals that could contaminate or harm the environment. This is not always possible but, if a choice needs to be made, then at least the product should be able to convert into compost that does not contain toxic glues and, when incinerated for its inherent energy, the gases are non-toxic.

10. *Use as few mechanical joinings as possible, rather snap fit*

In the clothing industry, buttons could be replaced with intricate knots that are produced from yarn that is hand woven.

A current example with snap fit applications is the cellular phones that have flooded the market and have become such fashion accessories, hence creating a very short product lifespan. If the plastics for these products were to be manufactured from a hemp-based plastic, the environmental impact could be reduced due to their biodegradability, recycle-ability, and sustainable resource origin.

6.5 Summary

There has been a discussion on the environmental impact of hemp in relation to other conventional materials, and what might be done during the design phase to promote an awareness of the steps needed for a successful sustainable product to be launched.

With these principles in mind, the next chapter will explore a few possibilities with reference to South Africa starting from the raw hemp material through to a viable and sustainable product.

CHAPTER SEVEN
DESIGN PROJECT

7.1 Introduction

The importance of finding a niché in the market with a new sustainable product based on old practises will be discussed in this chapter. An exploration on several levels of production complexity will be covered to ensure a further opportunity of success.

7.2 Motivation

The idea that *we are all designers* is a point that Donald Norman (2005) makes in his book *Emotional Design.* He states that any object produced by a creative mind with a pre set destiny can only function if the person uses it creatively in a new space for which he or she has acquired it. Norman explains: "A space can only be made into a place by its occupants" (2005:224). He also says that the role of the designer or creator is to empower the user with such a tool to achieve this end. The challenge is to develop products that people can utilise *for a long time in order to give a significant feeling of having grown with the use of the* product, and that the memories during ownership will reflect a personal pleasure in their present surroundings. Our lives are currently filled with too many prescribed designs with a set number of alternatives that hardly have any relevance to what we really prefer (Norman 2005:221).

To ensure a form of "emotional value which can be a worthy goal of design" (Norman 2005:224) we could search an old philosophical thought used by the Japanese called "Wabi Sabi". The principle behind this almost lost theory of Wabi Sabi focuses on the concept that every object produced is unique. The idea is to incorporate a designed flaw to simulate the uniqueness of the then mass-produced product. A strong emphasis is laid on minimalism, which is used to express elements of naturalness and reality through the spiritual and metaphysical realms (Koren 1994: 31). The elemental thought points to looking at what is prominently available in the direct surroundings and incorporate those inspirational ideas into creating a balanced aestheticism. This ancient concept almost embodies or describes the modern term "sustainability" that we are trying to reintroduce into this fast-tracked society.

The ideal is to design a *desired* object so that during its manufacture a personal touch is added to the process and, when a user can identify with this, it causes a point of reflection on the time and the state of mind in which it was created. In the world of mass consumption, there is hardly any recognition of what it took to make the product.

It seems as if we have lost touch with where goods derive from, what the resources have cost in the form of energy to grow or produce them, or from where the original resource arose. The world of the petrochemical industry has played an enormous role in the phenomenon of mass-produced consumer goods; it can be found almost instantaneously on nearly every shelf around the world.

This might be an excellent opportunity to institute a new way of interacting with what we have around us; and try to blend it in with the growth and waste that we create!

7.2.1 Incorporating

The design element of this thesis is based on a vision in which there is strong support for developing skills and job creation by investigating new materials such as hemp, and also looking at incorporating waste materials. As a consequence of this research, it has become rather clear that if applied properly, hemp can very well be a source of income to numerous levels of society to facilitate a sustainable technology. In South Africa, people have an amazing ability when manual labour is applied to the creation of society and culturally based crafts. The beading and wire crafts are all around and a new product surely can be introduced using a low-technology approach to uplift some of the less fortunate sectors of the society, giving them a sense of pride and affiliation; with the feeling of a nation moving forward.

7.3 Paper Project

7.3.1 Paper Making

The idea of papermaking can be one of the projects, which aid people in skill development, creativity and equipping people with relevance and a spark of innovation. The fibre of the hemp plant is an adequate base to produce hand scooped paper for various new products and in doing so gives the paper an added value. Joseph Diliza (2007) of Thando Papers based in Cape Town, produces paper and card from virtually any material suitable for the manufacture of these products.

Diliza (2007) is familiar with hemp but has mainly used it as a decorative feature on the surface of cards, this will be the first batch of 100% hemp he has been requested to make. The manufacturing of the paper starts with the removal of the bast fibres from the stalks; it then needs to be chopped or cut into lengths (Figure 7.3.1.1) of about 40mm otherwise it is too rugged to be processed properly. Diliza explains that after the fibres are reduced in size, they are weighed and placed in a vessel for cooking.

"I use a pot that can hold 10 litres of water; I place one kilogram of the chopped fibres in it, and fill it up to the 9 litre mark with water," says Diliza while he adds four tablespoons of caustic soda – which can be replaced with soda ash – to the mixture.

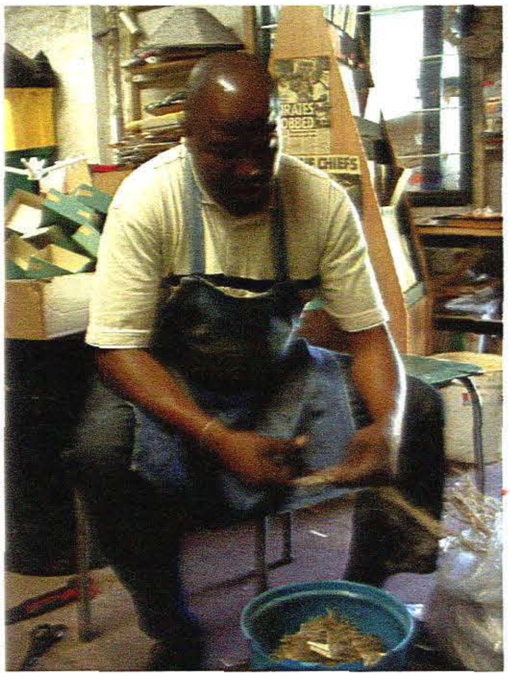


Figure 7.3.1.1: Diliza preparing the fibres for cooking in his studio

(Vermeulen 2007)

The mixture is brought to the boil and allowed to simmer for about two hours to soften the fibres before they are extracted and rinsed to remove the caustic soda. The paper can be bleached with sodium hypo chloride, which is 12% stronger than household chlorine bleach, but for this project it was decided to minimize the chemical additives. The rinsed fibres are then beaten in a machine to reduce the manual labour due to the bulk of paper that is made in the studio, but can also be done easily with a wooden hammer on a hard surface such as a concrete floor. The pulped fibres are then laid in a bath of water and scooped up with an A-4 size mesh frame; the thickness of the paper is determined by the amount of fibre scooped on to the mesh at one time. The wet pulp is then transferred on to felt where it can dry over night, but it can also be left on the scoop frame.

When the sheets are dry they are flattened in a press before they can be either sold or used in the manufacture of cards or boxes for weddings. Diliza has taught several people how to manufacture paper and they have subsequently created a living from it (personal communication, 8 November 2007).

The front and back cover pages are an example of hand scooped paper produced by Diliza.

Figure 7.3.1.2: A solar box cooker

(Solar Cookers International 2007)

A sustainability element that can be incorporated into this paper manufacturing project could be the building and installation of a solar cooker as the energy source for processing the paper product. Seeing that the paper pulp needs to boil for two hours it can easily be a shared daily task with food production if planned carefully. The box cooker (Figure 7.3.1.2) is one of the most commonly used solar cookers and is very easy to construct; it consists mainly of a box with a reflective interior that directs the heat rays towards the centre. The pots used for cooking should be dark as they absorb the heat better than a light one that reflects it. The cover can either be made out of glass or a heat-resistant plastic. It is best to insulate the box – this could be done with hemp insulation – and should be placed in a windless spot exposed to plenty of sunlight. The amount of sun available in South Africa is substantial enough to introduce such solar cooker technology. There are obviously start up costs involved, but the cooker will pay for itself quickly through the savings in fuel costs that are made during its lifespan (Solar Cookers International 2007)

7.3.2 Pop-up Card

It is of utmost importance to extend the value of the material and, through processing the paper into a commercially extended product, the goal of empowering the people can be achieved. In addition, this will ensure that the product will progress all the way from the agricultural point to a viable retail-able product.

The scope that came to mind during the research for a new product was once more emphasised by the diversity of South Africa's resources. It focuses mainly on the country's natural heritage and cultural richness. These are strong selling points in the tourist industry and the sale of curios can benefit immensely from this activity. It came to my attention that all the cards sold as memorabilia are either photographs or cards that are painted or decorated with beads and wire or other recycled materials. The concept of pop-up cards has not been explored as a viable option to translate our assortment of heritages.

With these ideas of paper and card material in mind, I was inspired and decided to run a workshop with the second year Industrial Design three-dimensional students at the Cape Peninsula University of Technology.

Part of the exercise was to gain as broad a view as possible from creative students and their interpretation of a brief for a commercial pop-up card. Their work was evaluated according to criteria such as design, originality and artisanship. Their brief stated that they should design a pop-up card with at least three separate depths, all to be done in monotone, and should fit into a size A5 envelope. The use of craft knives, scissors, rulers and glue (two-sided tape would be ideal for ease of use) were some of the tools they could keep in mind when compiling the card. The topics for inspiration could range from fauna and flora, nature, culture and heritage depicted through buildings, museums or people, but focusing specifically on unique topics related to South Africa.

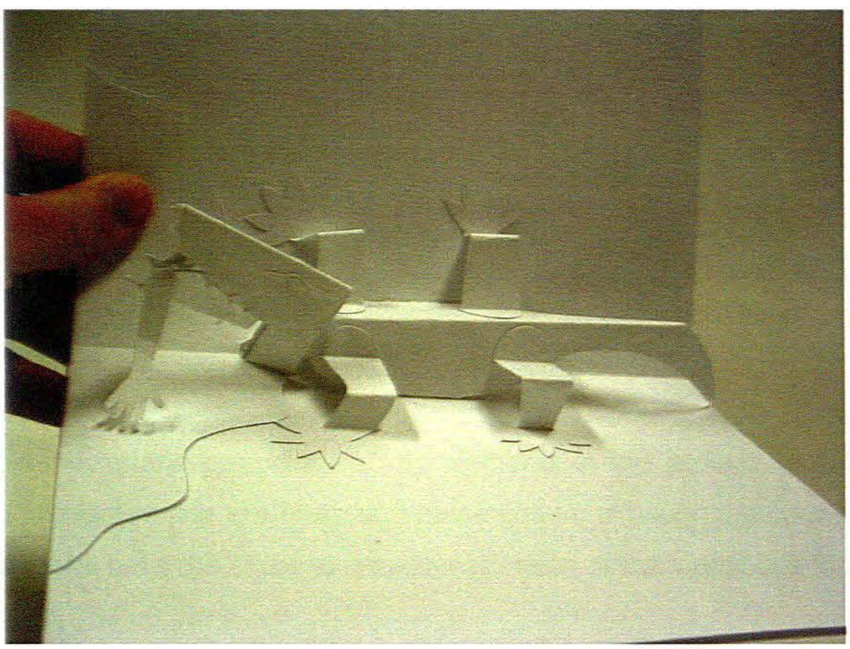


Figure 7.3.2.1: "Tastes like chicken" designed by Shritha Gungaya

(Vermeulen 2007)

After the briefing and numerous discussions about size, the monotone white colour and level of detail, the following examples were chosen from the range to give an idea as to what can be accomplished in such a project. An element of nature and humour were incorporated in the pop-up card designed by Shritha Gungaya (Figure 7.3.2.1) using a full three-dimensional figure to depict a unfortunate somebody becoming lunch for a crocodile and the victim of the beautiful nature that South Africa has to offer.

Micah Donnoli's design incorporated the four Nobel Peace Prize winners Albert Luthuli, Desmond Tutu, FW de Klerk and Nelson Mandela statues on the Nobel Square found at the Victoria and Alfred Waterfront, Cape Town to embrace the richness of key figures from our history (Figure 7.3.2.2). If a project such as this one was introduced into a creative community of people willing to develop a novel skill and craft, it could result in an exciting and flourishing new market.

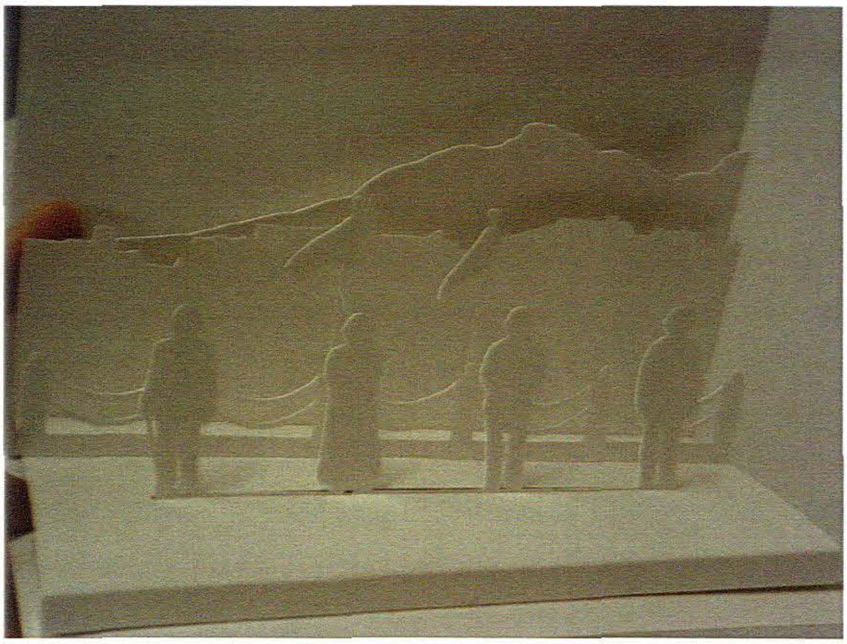


Figure 7.3.2.2: The Four Wise Men designed by Micah Donnoli

(Vermeulen 2007)

Even though creativity and patience are key elements in this project, the most important aspects in the production line are finish and presentation; although the card is handcrafted, its quality should still have the allure to draw the attention of the tourist and local markets.

7.4 Work in Progress

7.4.1 Grow Your Own Chair

The initial inspiration was kindled during my stay in Europe when walking through cultivated gardens such as Monet's in France. In the latter, in some areas the plants are pruned to alter their growth pattern, while in others they are woven together to create innovative structures. After returning to South Africa, I shared some of my findings with my colleagues, one of whom was Ziggy Strohbach, a three-dimensional and technical drawing lecturer. Strohbach kept asking questions about the speed of growth and strength to length ratio of the hemp plant. Thus, he awakened my curiosity and one afternoon I asked him why he was so interested in this topic.

Coming from a furniture design background, Strohbach found it fascinating how strong the plant seemed to be and what great potential it could hold on an experimental and creative level. The idea was then born to do some brainstorming about the possibility of growing a conceptual chair from hemp by altering the growth through weaving, pruning and bending.

Unfortunately, as mentioned previously, it is against the law to own any seeds in South Africa or grow them without a permit from the Department of Justice, Health and Agriculture. Therefore, this project is purely fictional, but here are a few concepts that were devised based on the samples required from the ARC to give an idea as to what the structural strength of a stalk could withstand.

7.4.2 Grow Your Own House

The South African Council for Organic Development and Sustainability (SACODAS) has been working on a plan that incorporates the introduction of hemp into the agricultural community, and includes the material in social-upliftment projects that will ensure job creation and skill development. The program has been progressing slowly due to the SACODAS' structure and governmental bureaucracy and all the implications this causes, including aligning the budgets. Recently the WCHI was installed by SACODAS to organise the farming aspect of the hemp plantations, and a division called Hemp Technology Initiative (HTI) is based in Cape Town.

The HTI team consists out of three environmental architects, a structural engineer and me. The first phase of the enterprise is to calculate the cost for an RDP scheme where a standard concrete home is built and next to it a hemp replica. This part of the project will be used to assess the characteristics of hemp in comparison to that of a conventional home based on temperature readings, sound and insulation factors, and acceptability. The next project would be a home designed from hemp with the same area as an RDP dwelling, and incorporating as many green sustainable factors as possible within a viable budget.

The main idea is to use land that has been allocated for this project and is currently infested with alien forestry such as the Black Wattle. When felled, these trees will be fed into the social housing scheme by using the lumber for the structural frameworks, which are then covered with cast hempcrete to complete the homes. The hemp crops for the building material can be grown on the land that was cleared and then lay fallow for a season.

Thierry Revert, one of the SACDOS board members, explains that besides this project, there are a few socially-orientated buildings designed for the future where hemp will be used to introduce this versatile material to the public. A Centre of Excellence is planned for the Sir Lowry's Pass and will be focusing on natural fibres. There will be a training centre that will teach people how to work with fibres, use display cabinets as informative tools, and a paper making department.

The location of the Agricultural Centre is not yet clear but the focus will be on local plant species and will house the first National Indigenous Seed Bank. A collection of open pollinated species will be available in the nursery at the Agricultural Centre. This could have a mayor impact on agri-tourism in South Africa. Another project that is being planned in *affiliation with the Stellenbosch University is an auditorium where the acoustic qualities of* hemp can be utilised (personal communication, 9 October 2007).

7.4.2.1 Ceiling Panels

To find a common ground for the previous three projects as described in 7.3.2 was rather challenging. Considering the lack of criteria with which to work, the idea arose to create ceiling panels; the inspiration came from the pressed ceilings found in old Victorian architecture. For each of these projects a unique design concept was developed to reflect the present theme in the structures. The panels can be made by using the Zelfo technique where a positive pattern is moulded out of clay on to which cement containing reinforcement is cast to create a negative imprint. The hemp pulp can then be sprayed into the mould to produce the required patterns in the panels.

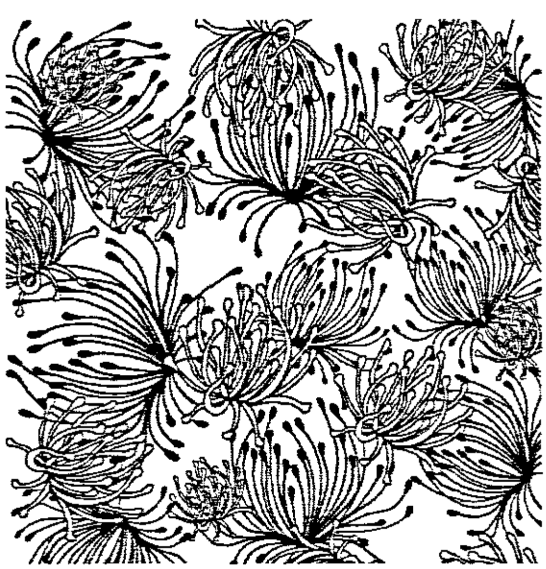


Figure 7.4.2.1.1: The Pin Cushion designed by Zani Fourie

(Fourie 2007)

Zani Fourie, a surface designer was involved in designing the ceiling panels. For the Agricultural Centre she chose the Pin Cushion (Figure 7.4.2.1.1) as a unique South African flora theme. The patterns do not run through with the adjacent panels, hence emphasising an element of nature, as there is no set structure in nature even though it creates harmony in its surroundings. For both panels have a surface dimension of 600mm by 600mm and a tab of 15mm on the adjoining sides, and slots removed from the other two.

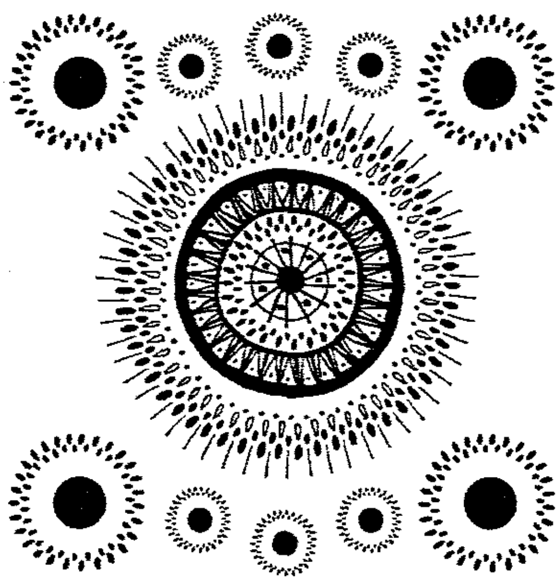


Figure 7.4.2.1.2: Circular pattern designed by Zani Fourie

(Fourie 2007)

The pattern for the Centre of Excellence embody examples of the Wabi Sabi concept, as the centre circle is slightly off centre and replicated in all the other arrangements. The circle (Figure 7.4.2.1.2) represents sustainability, as the fibres that will be used, displayed or process at the centre all derive from nature and can be returned to it composting reasons as it is a closed loop system.

The images of both panels are not portrayed in a two-dimensional manner and can be used as a guideline for the actual product. The creator of the actual panel has the freedom to incorporate different heights and depths to prepare a three-dimensional image that will then be replicated in the mould. There are a few aspects such as release angles and flow of material that have to be kept in mind while preparing for the actual object.

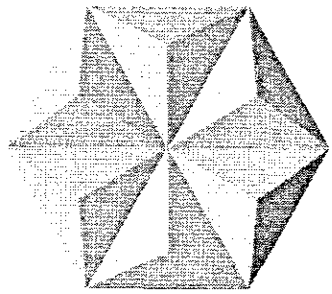


Figure 7.4.2.1.3: The *Asanoha* pattern

(Vermeulen 2007)

The *Asanoha* geometric pattern (Figure 7.4.2.1.3) is based on a hexagon with "six diamond–shaped design arranged in a radial manner (the pixel work of Mikio Inose 2007)" as a two dimensional representation. The layout of the lines gives the illusion that the pattern is three dimensional, which inspired me to translate the image into the raised motif. The set angle and the triangular patterns will most probably reflect and disperse sound in a positive way, making it an ideal panelling for an auditorium. It will be necessary to conduct tests to actually prove this statement, and the angles may require an adjustment. The completed panel (Figure 7.4.2.1.4) has a tab on two adjacent sides and the opposite sides have slots to accommodate the tabs (see Appendix B for more details). This will create a smooth overlay and compensate for the height difference. The panels can be mounted with screws on the battens that have been installed along the rafter beams.

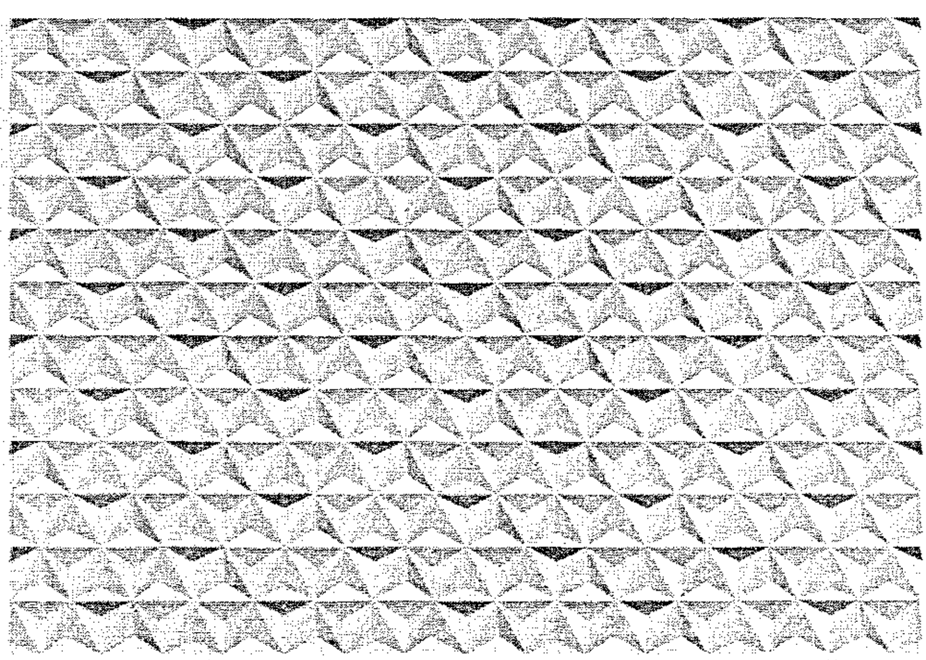


Figure 7.4.2.1.4: The *Asanoha* panel (700mm x 1070mm)

(Vermeulen 2007)

7.4.3 Sustainability Experiment

One of the fundamental rules of sustainability requires that a waste product be fed back into a new commodity. During a visit to Consol Glass' factory in Bellville, Cape Town in 2006, Abdul Abrahams, one of the shift managers facilitating the tour, highlighted the topic of exhaust fumes. As Abrahams explained, Consol Glass has taken a huge step towards the green concept and has invested millions of Rands to reduce the company's contaminated emissions. An exhaust fume scrubber was installed to capture dirt particles that are blown through a cloud of charged hydrated lime to absorb the impurities. By applying this principle, Consol Glass produces a staggering seven tons of waste lime/contaminate per day. The question has now arisen as to whether it will be viable to incorporate this waste lime into the manufacture of a hemp/lime mix. Consol Glass is willing to supply the waste lime at no charge, explains Abrahams: the company would rather see it go back into a new resource as opposed to the current practice of it being dumped. A transportation tanker is available: a critical aspect though is the storage of the lime, as it is very light and is easily air-born by a gust of wind if stored in the open.

Consol Glass is having a sample analysed by the Muller Labs to obtain a better understanding of the impurities contained in the lime. The main concern is to determine whether there is any trace of toxicity that might harm the environment or the people who are processing the waste product (personal communication, 17 October 2007).

Figure 7.4.3.1: Produced brick samples

(Vermeulen 2007)

The samples that were supplied for the experimental production of a few hemp bricks have a cream colour as opposed to regular white lime. To be able to determine if the lime waste material is suitable for the application of cast lime, a few sample bricks were fabricated. The ratio used was 10 volume parts hurd to 2.5 volume parts lime mixed with 4 volume parts water. The manufacture of a brick with a conventional size of 226mm x 108mm x 75mm required two litres of hemp to 500ml lime and 800ml water. A pair of rubber gloves was used to mix the components, while respiratory protection was used to prevent inhalation of the dust particles. The mixture was compressed into a prefabricated wooden mould lined with a plastic carry-bag to ensure easy removal when the brick had set (Figure 7.4.3.1).

After the lime had dried it almost pulverised when it was rubbed between the fingers. This was a strong indication that the lime had lost some of it qualities. On further analysis and observation, it became apparent that the lime had absorbed so many impurities that its structure had been altered in such a way that it had lost its proper setting capabilities. In conclusion, it is unfortunate that in this case it is not suitable to use the waste lime material for creating a new sustainable product.

7.5 Summary

It is apparent that hemp can be used in numerous projects within the South African context to produce quality products incorporating different scales of labour and technology. The conclusion will give a brief recap of how important of a role hemp can play on a sustainable level if unfounded prejudices are removed from the equation.

CONCLUSION

As a designer, there is a constant challenge to create a balance between people's demands and the clients' requests to translate an idea into a tangible shape that will intrigue the consumer and profit the inventor. There is a fine line between necessary and emotionally satisfying products, and the time has arrived when we need to be asking some serious questions relevant to the actual situation. It is not in people's interest for the market to be flooded with unnecessary goods that have a negative impact on the environment and are only driven by current trends.

Since the manufacture of mass-consumed goods cannot be avoided, at least we are obliged to incorporate the fundamental rules of sustainability into the equation to guarantee a better future for coming generations. If the current trend is sustained, we as inhabitants of this Earth as well as all other organisms are going to be poisoned under the banner of *development* by our chemical *cocktails* and combustible gases created by our *advanced* transportation inventions.

A vital issue is to get people to understand that we cannot continue with the old rhythms and that change is not a burden but a critical challenge to our very existence. Nature should grip our attention and motivate us to live at a reduced pace where there is time for reflection, paying respect to the elements and not harvesting them without dismay.

People have laid out ruthless rules and perceptions as to what nature is, and, by so doing; have warped a great deal of society's relationship with a phenomenon that we have perceived to be *normal*. Numerous cultures and nations have lived in close harmony with nature for centuries, but very often Western society does not acknowledge these structures, as they are considered not to be based on scientific facts. People have become rulers over nature and, in so doing, judge what is good for nature: this is most likely to cause a backlash, maybe sooner than later.

The concept of genetic engineering of seeds for mass crops is considered ridiculous: for example, their ability to reproduce has been eliminated; there is a patent on the right to buy seeds; and finally, only certain companies have the sole mandate to supply seeds. This phenomenon is an insult to what creation is all about and I maintain that a monetary value system should never be enforced on a gift from nature.

Crude oil and all the products derived from it are the cornerstones on which society's production is mainly focused. It is time to embrace nature and its bio-diversity. Hemp is one of the plants that offers a wide range of products and has the potential of playing a key role in future choices concerning design of environmentally-friendly commodities. The amount of energy that needs to be invested to transform hemp into applicable fibres or other items is negligible in comparison to what is presently being invested in the conversion of fossil-based products. Besides the energy saving aspect, the plant possesses natural healing properties both for humans and the environment: it can absorb heavy metals from contaminated soil. As stated in chapter five, because of its nutritional and immune boosting properties, it is invaluable to people suffering from epidemics such as HIV, AIDS and stress-related disorders. It is amazing to think that people could have a health solution growing in their own back yard. But alarmingly, this would impose a threat to the pharmaceutical companies' revenues that seem to be of greater importance than the state of a country's people.

We are all responsible for shaping the future; our governments should be the leaders in what needs to be done, and in setting the example: a rapid pace of positive growth can be achieved with a cleaner society rising from it. This task is enormous and will be difficult to start as we sometimes do not have a clear goal as to what the future does require, although growth, health, housing and safety should be the main topics of the day. Honesty and transparency are the keywords in developing this newly-designed program for a clean environment, not ignoring the possible innovative solutions.

In this dissertation, the goal is to demonstrate how the detrimental environmental impact of current practices might be alleviated by introducing hemp as a legal crop. Thus, hemp could become a potential saviour for the people in this all too fragile world, and have a positive impact on the South African ecology and economy. At this stage there seems to be a trend in South Africa to eliminate everything that is not indigenous. However, it should be kept in mind that the answer cannot be found in only one plant or a line of thought; we need to broaden the scope of what we have available in our surroundings and utilise this to its fullest potential.

The research on hemp could have a mayor impact on the country's economic growth, resulting in technical progress and the export of newly-developed products and knowledge. This paper may provide more clarity in order to resolve the imbroglio over hemp and exhibit how it can actually alleviate the peoples' problems, and without threatening them.

In some cases there needs to be a rather large investment in trust before we can translate old ideas back into current serious issues that this growing economy is striving to enrich. A feeling of excitement and hope should replace even the smallest doubt: a positive change in the government's attitude and the consumers' demand can possibly add to saving our very vulnerable eco system.

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Appendix A

Questionnaire on hemp **Design Indaba Expo 2007**

Gender: F (5) M (3)

Ages: 16-25 (3) 26-35 (3) 36-45 (2) 46-55 (0) 56+ (0)

What is hemp used for?

- For clothing, nutrition (seeds → Omega 3+6 +oils), building materials (lime + ash + stalks)
- Protein, oil, building, plastic, fuel
- Everything! Oil, food, clothing, building materials, plastic, etc.
- Various uses which I certainly was not aware of; textile, cosmetics, health, etc.
- Rope, straw hats, food, soap
- Clothing, paper, beauty products, cooking, plastics, textiles
- Making all kinds of items: clothes, building material, etc.
- Clothing, protein, construction, birthday products

When did you first hear of hemp?

- Have known about it for ages but not all the uses + properties
- In 1994 at school when I smoked some dope
- Long after I started smoking it
- About eight years ago in Johannesburg through the company House of Hemp
- Probably about five years ago
- About 15 years ago
- *Shop in Cape Town, four years ago*
- In 1996

Should hemp be grown in RSA?

Please explain your answer briefly.

- Yes. Job creation + natural organic approach to our environment
- Yes, it is a sustainable, eco-friendly crop that can create employment and also creates products that are environmentally friendly
- Yes. This is a sustainable and renewable energy source from which this country would benefit hugely
- Of course. There are great opportunities for the labour force in South Africa and could prove to be a formidable product in adding to the country's wealth!

- For manufacturing purposes, yes
- Yes, to help save our environment. In the manufacturing of natural & ecologically-friendly products
- Yes, it is a more than average, useful fibre
- Yes it is a great natural giver, natural and organic

What would you use hemp for?

- For healthy eating + clothing
- Everything I could. Food, cosmetics, plastic
- Clothing mostly and cooking
- Well I love the material produced from it and the cosmetic products produced from it
- Clothing, hats, mats, etc.
- Making clothes, sculptures, bed linen, hats etc.

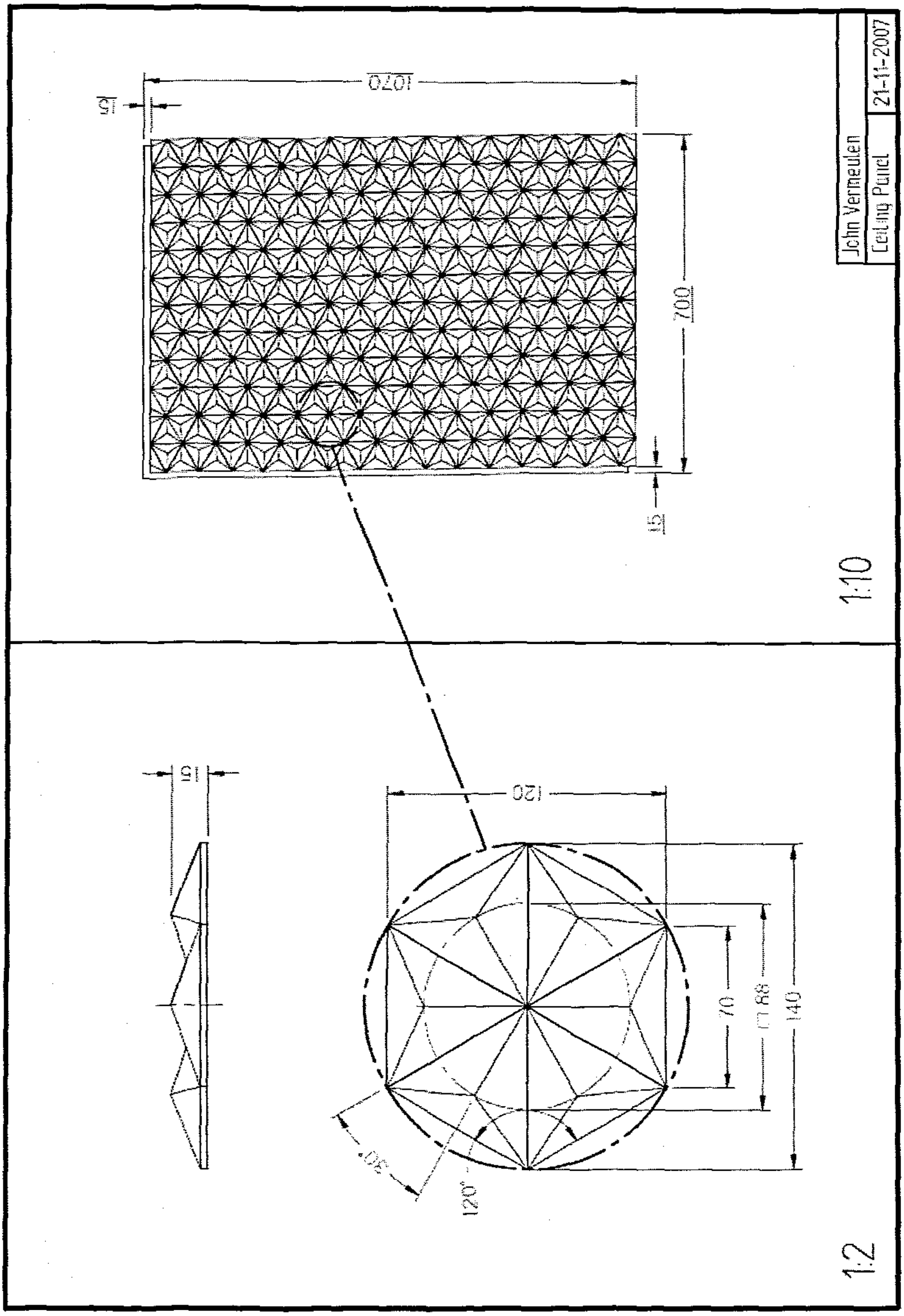
What impressed you most about hemp?

- It's so versatile + all its components are used (seeds, stalks, fibres) – so no wastage
- The versatility
- Tough and nutritious
- It's an absolutely different product all together and I'm attracted to how it supports my individuality
- Its versatility, that you could make such soft items as well as the durable stuff
- The strength and feel of the material. Its properties to be 'heavy'
- Its diversity

Should hemp be grown in RSA?

- Yes
- See other side
- Yes!
- Yes
- Yes

Appendix B



Not to scale