Potential of Hemp as an alternative sustainable component in building materials

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Abstract: *The purpose of this study is to investigate the level of awareness among industry stakeholders of the potential applicability of hemp as an alternative sustainable component in building materials in South Africa. The methodology used involved a review of literature followed by a document analysis of case study of a house built using hemp and supplemented by a questionnaire distributed to Architects and Contractors in South Africa. The key findings from the case study show that the house was built to be as organic and eco-friendly as possible and incorporated many green aspects. The findings from the questionnaires revealed that; the majority of the respondents agree that there is a need for exploring alternative building materials and they seem to have relatively high knowledge of what hemp is including the benefits associated with it. However, majority of the respondents were not certain whether hemp is readily available or not and this suggests the minimal use of the plant in South Africa. The study concludes that while there is some knowledge of hemp in the South African construction industry, it is still limited and its application thereof is also minimal. Current government regulations imposed on the cultivation of the hemp plant in the country equally seem to contribute to the minimal use of the plant in construction.*

Key words: Alternative building material, Green construction, Hemp, Sustainability, South Africa

Introduction

Buildings have significant impacts on the environment during their life cycles that is, from design, through construction, use, refurshment and adaption to demoltion and disposal (1,2). Various studies show that the use of conventional building materials has negative impacts on the environment (1). In recent years, there is an increasing awareness of sustainable construction and green building which include the need to explore different materials that could contribute to sustainability through saving water, energy and other resourcs and also reducing the adverse impacts of buildings on the environment and occupants.

Some countries such as the United Kingdom and Ireland are reported to be adopting the use of natural building materials because they provide a range of alternatives (2). Amongst the natural building materials currently available, hemp seems to be an emergent alternative green material, which although rarely utilised in the built environment in countries such as South Africa, has shown relatively high durability and eco-friendliness elsewhere (3). The problem

identified in this study is that there seems to be limited knowledge and application of hemp as an alternative component in building materials in South Africa (3). The paper takes the view that the perceptions of associated high costs and legal restrictions limit the wider use of hemp in the South African construction industry. The purpose of this study is to investigate the potential benefits of hemp as an alternative component in building materials as well as its sustainability. It also seeks to estblish the level of knowledge of selected industry role players of hemp as an alternative green material.

Building with Hemp

The hemp plant native to Central Asia is a member of the Cannabis Sativa family of which marijuana is part of (4, 5). The main difference between hemp and marijuana lies in the content level of tetrahydrocannabinol (THC). In hemp the THC content level is estimated to be approximately only 0.3% and deemed insufficient to cause any physical or psychological effects compared to marijuana which contains between 15-20% (5). Although hemp and marijuana are plant cousins, the two plants are cultivated for different uses. Due to environmentally friendly properties of hemp, the Chinese construction industry started making internal and external floor coverings, plastic reinforcement and lightweight boards with hemp pulp (6). However, in South Africa, the relationship between hemp and marijuana led to hemp being made illegal since 1903 when the marijuana prohibition Act was passed (7). Nonetheless, the South African government recently issued permits for the growing of 700 hectares of hemp in the country for research purposes. Despite that hemp may not be grown on a large scale in South Africa, plans are underway to set up a hemp fair trade structure (8).

Hemp is becoming a significant alternative in the search for alternative building materials because it is a renewable and environmentally friendly plant (9). There are a number of products which have hemp as a component including the following: hempcrete, hemp bricks and hemp paints:

- Hempcrete – hempcrete is a term used to define lightweight, insulating and breathable material produced by mixing hemp-shives with a lime base binder and water (9). This mixture allows the hempcrete to have different mechanical and acoustic properties to those of conventional concrete (10). The lime consists of additives such as pozzolan which is an aluminous material that possesses little or sometimes no cementious properties (11). The presence of highly reactive aggregates in the conventional concrete often damages it, but research shows that the use of pozzolan is highly beneficial and that it is a strength and durability improving additive (12). Hempcrete can be used for insulation quilts, floors, roofs, screed, mortar or insulation plaster which can either be cast or spray applied (9).

- Hemp bricks: hemp shives are mixed in a similar way as hemcrete where the mixture is poured into a timber framework to set and form bricks (12). These types of bricks are relatively easy to work with in comparison to common brickwork. The lime in the mixture holds the brick together and protects it against water penetration from the external moisture exposed surface (12).

- Hemp-based paints: hemp seed is used for a variety of products such as body care products, pharmaceuticals, industrial oils and paints (4). Hemp paints have superior coating and durability characteristics, while most conventional paints and wood preservatives finishes have a high volatile organic compound level (VOC) which is harmful to the environment (14). Hemp oils give a natural finish and higher protection with low VOC level (14).

Research Methodology

A case study of the first house built out of hemp in South Africa was analysed. Hemp houses are rare in South Africa and this provides an opportunity to better understand the process of incorporating hemp as a component in building materials. A structured questionnaire was also sent out to 10 contractors and 10 architects in order to obtain the respondents' knowledge and view regarding climate change and hemp. Simple descriptive statistics were used to analyse data obtained from the questionnaires.

Presentation and Discussion of Results

The case study involves a house built with hemp in Noordhoek, Cape Town South Africa. Basic details include;
Owner: Tony Budden
Architect: Wolf of Wolf & Wolf Architects
Structural Engineers: Michael Orchard and Tony Davenport
Construction period: November 2011 to August 2012

<u>Components of the house built with hemp</u>

- Foundations - A hemp strip foundation was used on the steep plot.
- Hempcrete walls - 300mm thick walls were built from a wood frame made of shutter boards. The hempcrete mixture which consisted of 100 litres of hemp to 25 kg of binder and 27 litres of water was cast into the boards in layers of 40 – 50cm at a time. The hempcrete mixture produces breathable, organic, insulating, light and durable walls. The walls were hemp insulated, plastered with hemp screed and finished off with lead free, zero VOC release eco-paint.

This case study suggests that costs may be saved if masonry walls are replaced with hempcrete walls because hempcrete walls are lighter, yet durable. Durability seems to be a

given with regards to hempcrete structures. Attention was given to quality as the indoor paint finishes consisted of zero VOC release eco-paint.

- Roof – the plant matter taken from the ground where the house is built was placed on the roof of the house. This not only preserves the grass but also allows the roof to insulate the house during the winter and cool it during summer, hence reducing the amount of energy required to heat and cool the house.

- Windows – the windows used for this house are double-glazed and have an automated opening system attached to a thermostat. The thermostat helps to regulate indoor temperature as well by opening the windows on the cooler or hotter side of the house, depending on the season.

The features above indicate that that the construction of the hemp house took into account as many green aspects as possible in making the house more ecologically friendly.

Findings from the Questionnaire

Regarding the work experience of the 20 respondents, it was found that the majority (66.67%) have more than 5 years in the building industry with 16.67% having over 20 years experience. The level of the respondents' understanding and/or knowledge of some aspects of the concept of green building were examined and the results shown in Table 1.

Table 1: Respondents' level of awareness of green building

	Frequency						
	Strongly disagree		**→**		**Strongly agree**	**Mean**	**Rank**
	1	**2**	**3**	**4**	**5**		
There is global climate change.	0.00%	5.56%	11.11%	33.33%	50.00%	4.2	3
The built environment is a major contributor to climate change.	0.00%	22.22%	22.22%	44.44%	11.11%	3.5	4
I understand what the green building initiative is.	0.00%	0.00%	16.67%	16.67%	66.67%	4.5	1
I am familiar with the Green Building Council of South Africa.	0.00%	5.56%	11.11%	22.22%	61.11%	4.4	2
I am familiar with green building materials.	0.00%	5.56%	11.11%	38.89%	44.44%	4.2	3
I think there is a need for							

alternative green options in building materials.	0.00%	0.00%	22.22%	33.33%	44.44%	4.3	3

Table 1 shows that all the statements scored mean scores of above 3, (3.5 to 4.5) which suggests that respondents were in agreement with all the statements posed to them. From the results, it is evident that 50% strongly agree and 33.33% agree with the statement that "there is global warming", which constitutes a majority with a high mean of mean 4.2. When there is awareness and knowledge of a particular problema, it is easier to attem to find a solution. The majority (83.33%) of the respondents with a mean of 4.3 agree that they are familiar with green building materials. Similalry, the majority of the respondents (77.77%) agree that there is a need for more alternative green building materials. This indicates that the built environment needs to seriously consider a paradigm shift away from the use of conventional materials towards environmentally friendly materials. The literature showed that the built environment is increasingly moving towards the construction of green structures, however, the goal of building green will not be fully achieved until the materials used are green and eco-friendly. These findings suggest that there is a sense of synergy among people in the industry in trying to minimse the impact of building on the environment and global climate as a whole.

The respondents were asked to indicate their level of agreement or disagreement to a number of statements related to hemp as an alternative building component. The results obtained are presented in Table 2.

Table 2: Hemp as a green building material alternative

	Frequency					**Mean**	**Rank**
	Strongly disagree		**→**		**Strongly agree**		
	1	**2**	**3**	**4**	**5**		
I know what hemp is.	11.11%	16.67%	0.00%	44.44%	27.78%	4.1	1
Hemp is readily available.	5.56%	33.33%	44.44%	11.11%	5.56%	2.8	7
I am aware that the cultivation of hemp is prohibited in South Africa except for research purposes.	5.56%	33.33%	33.33%	5.56%	22.22%	3.1	4
I am aware that hemp may be used as a component in building materials.	5.56%	22.22%	5.56%	33.33%	33.33%	3.7	2
I know the various building materials which have hemp as a component.	22.22%	22.22%	22.22%	22.22%	11.11%	2.8	7
I am familiar with the construction techniques of hemp.	22.22%	22.22%	27.78%	22.22%	5.56%	2.6	8
I am aware of the benefits of							

hemp.	16.67%	27.78%	5.56%	38.89%	11.11%	3.2	3
I think hemp is a sustainable alternative component in building materials as compared to conventional materials.	11.11%	16.67%	44.44%	22.22%	5.56%	2.9	6
I think hemp is environmentally friendly.	5.56%	22.22%	44.44%	22.22%	5.56%	3	5
Hemp is more cost effective.	5.56%	22.22%	27.78%	33.33%	11.11%	3.2	3

Table 2 reveals that while the majority of the respondents (72.22%) with a mean of 4.1, indicated that they know what hemp is, the statement which ranked the least (8) (mean 2.6) shows that the respondents are not familiar with construction techniques of hemp. The only two other statements which also scored mean scores of less than 3 had to do with knowledge of materials that contain hemp and the sustainability of hemp as a component in building materials respectively. This a poor reflection of the knowledge levels of the respondents.

The case study indicates that South Africa built what is deemed the first hemp built house in 2012. These findings indicate minimal usage of the material in the country although 50% (mean 3.2) of the respondents agree that they are aware of the benefits of hemp. This shows that although the respondents know what hemp is, the knowledge is still limited. The respondents were asked about what they thought the reasons or challenges associated with the use of hemp as a building component in South Africa were, the results are as shown in Table 3.

Table 3: Limitations associated with the use of hemp

	Frequency						
	Strongly disagree		**→**		**Strongly agree**	**Mean**	**Rank**
	1	**2**	**3**	**4**	**5**		
I think hemp is not widely used in the South African construction industry because it is not locally grown.	0.00%	16.67%	44.44%	16.67%	22.22%	3.4	2
I believe the thought of importing hemp makes developers reluctant to make use of the plant.	0.00%	16.67%	33.33%	27.78%	22.22%	3.5	1
I think the South African government should legalise the cultivation of hemp so that it can be used as a component in building materials.	0.00%	22.22%	16.67%	44.44%	16.67%	3.5	1

Table 3 shows that that the results for all the 3 statements were merely over 3 (3.4 and 3.5). This may suggest that although 33.33% of the respondents are not certain whether or not the thought of importing hemp is what causes developers to be reluctant in utilising the plant, 50% do agree with it. The majority of 44.44% (mean 3.4) are unsure if the minimal use of hemp in the South African construction industry is due to the lack of having hemp locally grown. More than half (61.11%) of the respondents agree that the South African government should legalise the cultivation of hemp so that it can be used as a component in building materials. While the literature shows that hemp may not be grown in South Africa except for research purposes only, plans are underway to set up a hemp fair trade structure in the country. This may suggest that the government might be considering restructuring hemp's legal status in the country.

Conclusion and recommendations

The main findings of the empirical study revealed that although the majority of the respondents know what hemps is, they however do not seem to know the construction techniques associated with it. This demonstrates the minimal use of the plant in the South African construction industry. Majority of the respondents agreed that the cultivation of hemp should be legalised in South Africa which suggests that professionals would like to see the construction industry moving forward towards sustainable construction. The majority of the respondents were not certain whether the minimal use of hemp in the South African construction industry is attributed to the high costs associated with the plant. However, the majority of the respondents agree that the South African government should consider changing the legal position of hemp in the country and allow for its cultivation.

From the findings, it seems there is knowledge in the construction industry regarding the use of hemp as a sustainable component in building materials, however the knowledge is limited and thus it is also not applied effectively. South Africa has only one house which is built out of hemp, and from the case study findings it shows many environmental benefits. Based on the findings, the study concludes that there is indeed limited application of hemp as an alternative component in building materials.

There is need for continous profesional development of people who have already working in the construction industry about the benefits and application of hemp. It is also recommended that the Green Building Council of South Africa should advocate for legalising the cultivation of hemp in South Africa and highlighting the properties and benefits of hemp. Continuous evaluation of the success of the case study reviewed must be done in order to keep track of the financial and sustainable performance of the house. It is also recommended that a further study of the financial or cost implications of the hemp-built house be undertaken to give a better understanding of the costs involved in construction and maintenance. Similar studies should also be undertaken in other countries to establish what outcomes would emerge

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