
The Applicability of HEMP in Building Construction

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ABSTRACT

The environmental impact of construction activities has risen considerably in recent decades. Greenhouse gas emissions are primarily emitted by buildings. Alternative green construction materials are necessary to reduce the environmental impact of building construction. Hemp is one such environmentally beneficial substance. Hemp is a plant-based material that can be used in a variety of construction applications.

The purpose of this research is to see if hemp can be used in building construction. This paper will examine the many types of hemp used in construction, as well as their performance, by looking at case studies of buildings that have employed hemp as a construction material.

Keywords:-*Sustainable, alternative construction material, greenhouse gases emission in construction, CO₂ Gas emission.*

INTRODUCTION

The term "sustainable" is becoming increasingly popular around the world. Sustainable building systems can have a direct impact on the improvement of community livelihood conditions through selecting appropriate design, materials, construction processes, and building operations and maintenance.

Unfortunately, the extraction of natural aggregates has resulted in the establishment of man-made quarries, which have a significant environmental impact on the environment. This has been a huge source of concern around the world.

As a result, the study's main purpose is to provide or pave the way for improved sustainable construction design concepts and methods. To reduce the impact on environment, the construction industry must react and develop innovative designs and materials.

Although most people are aware of hemp, we are hesitant to discuss it because of its controversial nature in today's society.

Hemp has been one of the most important and largest agricultural crops in human history as a historically and culturally significant plant.

Hemp is considered as an essential dietary and high protein resource for human and animals due to its nutritional values. Including construction and architectural field industrial hemp is already being used in other various industries.

Hemp's popularity has grown as a result of its natural qualities and "environmental benefits in terms of energy savings throughout construction phases. "Hemp is a more environmentally friendly raw resource than other currently used materials, and the finished product is likewise carbon negative.

This indicates that hemp can absorb more greenhouse gases over its lifecycle than it emits during the manufacturing process (R  h & Barbu, 2017).

NEED OF THE STUDY

Climate change is a biggest fear of our near future. Construction of building is responsible for causing approximately half of the total Greenhouse gas emission. To reduce the environmental impact of construction alternative sustainable materials are required.

Hemp being a natural material can be a possible alternative because it has the potential to reduce the emission of greenhouse gases.

UNDERSTANDING HEMP AS A CONSTRUCTION MATERIAL

Hemp as a Plant

Cannabis plants have a rich history. It contains a great potential for the future as it can be used variously in different industries. This plant is determined to be an alternative building material as per today's greening trend.

Types of Basic Cannabis Genera

There are three types of basic cannabis genera:

Rum Cannabis (*Cannabis ruderalis* Janisch): It is a perennial weed. It contains lower amount of THC which means it does not cause any significant narcotic effects. It is native to central and Eastern Europe and Russia.

Indian Cannabis (*Cannabis indica* Lam): Indian cannabis contains high amount of THC (tetrahydrocannabinols) which causes psychoactive effects. It contains

more than 0.3% of THC in dry matter which has significant narcotic effects.

Cannabis (*Cannabis sativa* L.): It is termed as technical hemp in other words. It is an important herbaceous species of plant. It is originated from central Asia. It has been used in various industries such as textile, medicinal from a long period of time.

This plant has a rapid growth and because of its multipurpose applications, it is becoming a point of interest. It generally grows from 2-6 feet and suppresses the growth of weeds.

This plant does not require any pesticides or herbicides or growing. It has a growing period of 100-120 days. This plant is a rich source of cellulosic and woody fibers and phytochemicals.

It has roughly 23% fibre content and 75% shive content (woody mass). Pharmaceutical and construction sectors are highly interested in this plant because different parts of this plant can be used in certain ways to produce bioplastics and concrete like material.

Technical Hemp

Technical hemp or industrial hemp is the fastest growing plant as bamboo. It belongs to the family of cannabaceae.

Technical cannabis is an organic crop that may be used in a variety of ways. Hemp can be used to make up to 25,000 100% recyclable products. Hemp is sometimes mistaken with the marijuana, another species of cannabis plant and the drug preparation hashish. Biomass (fibre, shive) and seed are the most basic usable raw materials.



Fig.1:-Varieties of hemp[19]

PHYSICAL DESCRIPTION

Hemp is an erect annual herb that is robust, aromatic, and aromatic. Except at the tip and base, the slender cane-like stalks are hollow. The blooms are tiny and greenish yellow, and the leaves are

palmately complex. On pistillate, or female, plants, seed-bearing flowers grow in elongate, spike-like clusters. Pollen-producing blooms of a staminate, or male, plant generate many-branched clusters.

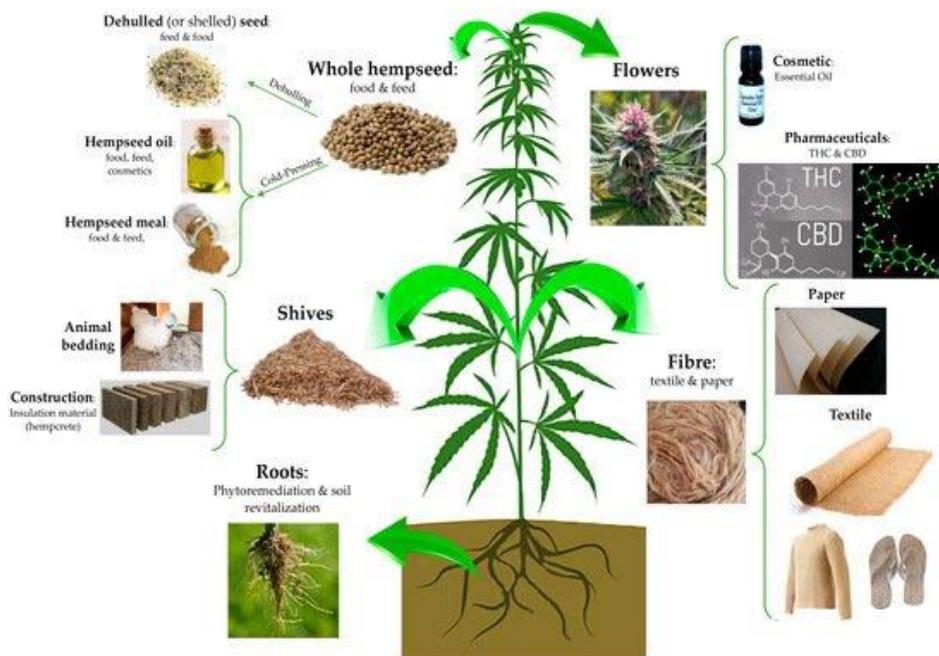


Fig.2:-Physical description of hemp

CHARACTERSTICS OF HEMP

- **Low Embodied Energy-** Hemp does not require much processing in order to be produced, thus it is good for the environment.
- **Carbon Storage-** During its existence, it absorbs a substantial

amount of CO₂ from the atmosphere. Each tonne of fibre harvested throughout its growing stage will store up to 2 tonnes of CO₂.

- **Thermal Insulation Properties-** It's medium-density insulation that's not only safe but also effective and long-

lasting. Because of its low conductivity and big thermal mass, it can retain heat and alter thermal performance for a comfortable indoor atmosphere.

- **Breatheable-** Unlike most other insulation materials, it can absorb up to 20% of its weight in moisture and maintain its function. It may then release the moisture as needed, allowing the internal humidity to be controlled. Mold doesn't grow on hemp.
- **Non flammable-** Mixture of hemp and lime is completely non-inflammable.
- **Lightweight-** Being lightweight it may be utilized in lofts, walls, and inter-floors, expanding its variety of applications in the construction business.
- **Recyclable-** Hemp can be completely decomposed. It is biodegradable and non toxic.
- **Low maintenance-** It does not require herbicides or chemical pesticides to grow and requires very little water.

HEMP IN CONSTRUCTION INDUSTRY

Because of hemp's environmentally friendly properties, the Chinese construction industry began using hemp pulp to make internal and external floor coverings, plastic reinforcement, and lightweight boards. Hemp is becoming an important alternative in the search for alternative building materials because it is a renewable and environmentally beneficial plant. Hemp is used in a variety of products, including hemp Crete, hemp bricks, and hemp paints.

USE OF HEMP IN CONSTRUCTION Hemp Based Paints

Hemp seed is utilized in cosmetics, pharmaceuticals, industrial oils, and paints, among other things. Most conventional

paints and wood preservative finishes include high quantities of volatile organic compound (VOC), which are detrimental to the environment. Hemp paints have excellent covering and durability qualities. With a low VOC level, hemp oils provide a natural finish along with increased protection with lower levels of volatile organic compounds.

Hemp oil, like the plant as a whole, is mould resistant and repellent. It is a completely natural, biodegradable product with a higher resistance to water soaking. This oil also keeps the surface of the wood permeable to water vapour, allowing it to breathe.

In general, the interior construction is sufficient to repaint pure cannabis oil, which is also suitable for coatings of furniture, toys, and so on due to its pure natural composition. Because this oil is not totally UV-resistant, it is important to treat the exterior elements with other methods, such as a hemp lacquer lacquer that also contains mineral pigments to protect them from UV rays, ensuring that the wood is perfectly preserved for many years.

HEMP INSULATION

This natural substance offers a healthy interior atmosphere by producing a pleasant microclimate and providing natural protection against mould, rot, and pests. Cannabis has comparable thermal and acoustic capabilities to traditional insulations, but its moisture resistance and capillary water drainage properties ensure durability even when traditional materials are degraded or have considerable losses in isolating properties.

With a thermal conductivity of 0.38 to 0.4 W/(m²K), hemp fibre insulation is one of the better options. Hemp insulation is sufficiently flexible to revert to its original shape after a brief period of compression

due to the toughness of the hemp fibre. Because it is impossible to avoid squeezing the mat while inserting between structural parts, this feature is especially critical when assembling. Simultaneously, the cannabis insulation keeps its shape for a long time, preventing cavities from forming where the insulation should be.

HEMP BRICKS

Hemp shives are blended similarly to hemcrete and placed into a wooden framework to set and form bricks. These types of bricks are relatively easy to deal with when compared to traditional brickwork. The lime in the mixture binds the brick together and protects it from external moisture penetration via the exposed surface.

HEMPCRETE

Hemcrete is a lightweight, insulating, and breathable material manufactured from hemp fibers, a lime base binder, and water. Hemp Crete has different mechanical and acoustic qualities than traditional concrete. Pozzolan, an aluminous substance with little or no cementitious qualities, is one of the additions in lime.

The presence of highly reactive particles in ordinary concrete commonly causes it to fail, however research has shown that using pozzolan as a strength and durability increasing additive is quite advantageous. In practice, lime is made by restricting the amount of calcined limestone used and burning it at temperatures exceeding 825 degrees Celsius. CO₂ is produced as a result of this process. Lime is being procured.

The slaked (hydrated) lime is converted to heat by the addition of water. The so-called Hydraulic lime, whose components react with water and hence encourage a quick rise in strength and partial water resistance during the ageing of the hemp-

lime building substrate, is used instead of the traditional hydrated lime. Pozzolans, which comprise silicates, are found in hydraulic lime. Because of the absorption of atmospheric carbon dioxide, lime is transformed once more into limestone, or "stone."

The materials that are covered in lime are also changed. The shive contains a lot of silica, it petrifies (hardens to fossilization) when it comes into touch with lime, making it an excellent building material. The substance extracts CO₂ from the air and purifies it during mineralization. This is an excellent building material. During mineralization, the material collects CO₂ from the air, cleaning it.

Depending on whether the combination is for a wall, roof, or floor, the percentage of basic components varies. The resulting hemp lime concrete composite is light (up to 7 times lighter than regular concrete) and hence easier to work with without heavy gear. It's a biodegradable substance with excellent thermal and acoustic insulation properties.

Working with the construction mix does not necessitate any special knowledge. Hemp concrete is frequently squished into formwork for constructing walls. When insulating the roof, it is a little looser. Aside from being a universally usable and cost-effective building material, hemp concrete is also environmentally friendly, with an A+ environmental balance.

HEMP AS A SUSTAINABLE MATERIAL

Hemcrete structural blocks and panels could become a viable alternative to standard cement blocks and timber framing due to their rapid growth. This could help to relieve pressure on the world's forests and lessen the estimated 15 billion trees cut down each year. Increased carbon capture would result from less

deforestation, providing a natural solution to prevent global warming.

Hemp is also inherently resistant to fire and mould. As a result, builders will be able to lessen their reliance on chemical fire retardants, which have been linked to a variety of health issues. Hemp provides the sustainable construction industry with a bio-based product that is nearly carbon

neutral and can be used in a variety of applications. Hemp can be grown locally as a sustainable agricultural resource without the need of numerous agrochemicals. It could also be a valuable crop for reviving and strengthening rural economies.

APPLICATION OF HEMP IN CONSTRUCTION

Case Examples

Case Study 1: Marks & Spencer Cheshire oaks

Tangible aspects
Project Location: Cheshire, UK.
Project Type: Commercial.
Site area: 2, 10,000 sq. ft.
Surroundings of the building: Residential area
Year of Completion: 2017
Architect: Aukett Fitzroy Robinson

Introduction about the project: It is the second largest M&S shop, as well as the largest built from the ground up, and is located near Liverpool. The 210000 square-foot facility was constructed as part of their Plan A commitment to produce the most environmentally friendly and carbon-

efficient building project feasible. The knowledge and experience obtained from these stores adds to a significant library of sustainable practices knowledge and experience that M&S plans to incorporate into standard requirements



Fig.3:-M&S store cheshire, oak

Contribution of Hemclad: Hemclad was selected for all non-glazed elements of the façade because its thermal mass and inertia properties were calculated through

rigorous thermal modelling, resulting in M&E plant (heating and cooling) reductions as well as reducing the energy in-use.

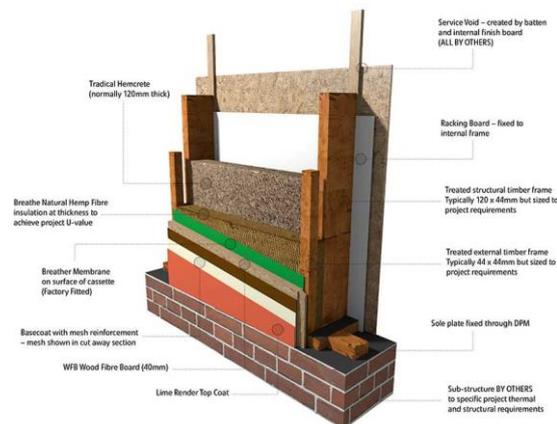


Fig.4:-Hemclad panel section

- Energy: 42 percent reduction in energy use compared to an equivalent store was achieved, compared to a target of 30 percent. The store used 21% less electricity and 60% less heating fuel than originally estimated.
- Carbon emissions: compared to a target of 35 percent, this store emits 40% less carbon than an equivalent store.
- Insulation: The use of bio-composite Hempcrete panels, as well as rigorous design and construction detailing, resulted in a high level of insulation. The building's airtightness was determined to be 70% better than necessary by Building Regulations, with heat loss of less than 1°C overnight in winter, compared to 9°C in typical store environments.
- Hemclad "infill" panels covering 2600m² on a primary/secondary frame. Steel and glulam materials were used to construct this frame. Hemclad panels with dimensions of 3.8m x 2.4m were made. Panels have a 0.12U value and a twin-stud configuration to prevent thermal bridging – total 400mm deep with 200mm factory-cast Hempcrete and 200mm Breathable hemp-fibre quilt. After comprehensive thermal modelling, the specification was

decided to provide the optimal balance of thermal mass to meet retail store thermal dynamics and optimize the heating/cooling plant.

- During the growing of hemp insulating material, 80 tonnes of CO₂ are locked up and stored in panels. When compared to typical infill, this material is estimated to save 340 tonnes of CO₂.

Case Study 2: Casa di Luce, Italy Tangible Aspects

- Project Location: Puglia, Italy.
- Project Type: Residential.
- Site area: 3200 sq. meter.
- Year of Completion: 2016
- Architect: PS architecture.

Introduction about the project

Casa di Luce is a nearly net zero energy consumption and also the part of sustainable urban regeneration. The project was built with an integrated and holistic approach. The construction was based on the theme of environmental sustainability, bio-architecture, comfort and housing.

Contribution of Hemp

Biomattone blocks were used to build the nonstructural walls of the building. Biomattone is the composite of hemp and

natural lime binder. It was the principle product used in the building.

- Benefits of Biomattone
- Permeability towards the water vapor.
- Resistivity toward the fire, frost, insects and rodents.
- Free from toxic fumes in case of fire.
- Capability of sequestering and absorbing CO₂.
- High environmental compatibility and recyclability.
- Productions of the biomattone have low energy consumption and nearly zero environmental impact.
- Mixture of hemp and lime helps in maintaining the comfortable indoor environment by limiting the change in temperature through its insulation properties which also helps in reducing the energy consumption.



Fig.5:-Biomattone

Case Study 3:-Mullumbimby Hemp house

Tangible aspects

- Project Location: Mullumbimby, NSW North Coast
- Project Type: Residential.
- Site area: 210 sq. meters.
- Year of Completion: 2015
- Architect: Barefoot sustainable design

Introduction about the project

The Mullumbimby Hemp House was designed to be a model of low-cost ecological housing. It was designed to house a small family of four and fit on a small residential lot. The house was created as an example of low-cost ecological housing, with monolithic hemp serving as the primary building material.

Contribution of Hemp

- The 300mm thick walls were constructed with an Australian Hemp

Masonry Company (AHMC) binder and hemp.

- Hemp has contributed in providing excellent thermal and acoustic insulation.
- Hemp is fireproof and termite resistant, inhibits mould growth, and is naturally airtight.
- Hemp also absorbs CO₂ from the environment.

CONCLUSION AND RECOMMENDATIONS

The primary goal of this study is to investigate and assess the various applications of hemp in building construction.

There are numerous construction materials with excellent properties that are used in the construction industry. The manufacturing of these materials, however, has a direct or indirect impact on the environment.

Hemp is a plant-based substance. CO₂ is absorbed and sequestered in the process of producing hemp and creating hemp-based materials, while CO₂ is created in the processing and extraction of other building materials. Hemp is a sustainable material. It can be used in place of a variety of other building materials.

Although hemp's structural application is still debatable due to its poor compressive strength but load bearing hemp blocks are being manufactured around the world. They are used for constructing load-bearing walls.

These blocks are lightweight and easy to work with. Certain techniques are used to increase the remoteness of these blocks and provide them with extra support.

Hemp can be utilized in building in a variety of ways, including:

- Hemp-based paints have a low VOC content, which is good for the environment.
- Hemp blocks or bio-mattones can be used to construct the non-load bearing walls.
- Hemp and lime mixtures in a definite proportion can be used for plastering the interior and exterior walls.
- Hemp based varnishes can be used to preserve wood.

Sure, hempcrete has more environmental benefits, but when it comes to building structures, the most crucial consideration is safety and hempcrete cannot provide the guarantee that the structure can support itself.

Limitations of working with Hempcrete:

- Hempcrete just does not provide the same level of crucial performance as conventional concrete.
- Hempcrete cannot be used for structural purposes because of its low tensile and compressive strength.
- Hempcrete cannot provide structural stability to a high rise construction.
- Because hempcrete absorbs water, it can't be utilized to build dams or bridges because it can't hold a lot of it.

Alternative ways in which Hempcrete can be used:

- Hempcrete can be used in a single Storey residence building where structural load is less.
- It can be used in making the non-structural walls of any building.
- It can be used Hemclad paneling (Composite panel made with hempcrete and wood) as used in Marks & Spencer store.
- It can also be used in partition walls.

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