POSITION PAPER FOR THE INTERNATIONAL HEMP BUILDING ASSOCIATION ON:

THE APPROPRIATE MEASUREMENT OF HEMP AND OTHER NATURAL BUILDING MATERIAL PERFORMANCE.

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In an era of climate change, the environmental impact of the construction sector is increasingly required to meet sustainable development criteria. Buildings and their materials need to ensure that: resources are used efficiently and waste is minimised by closing cycles – pollution is limited to levels which natural systems can process without damage – natural diversity is valued and protected – local needs are met locally where possible – good food, water, shelter and fuel are available to all at reasonable cost – satisfying work in a diverse economy is available to all – good health of the community is protected – environment is not damaged by access to facilities, services, goods, and other people – local distinctiveness and character are valued and protected.

Currently building materials are required to perform in a narrow selection of behaviours which only partially describe a value of energy behaviours, that of thermal conductivity or resistance. This does not address the need for intelligently addressing the impact or performance of a particular material singly or in combination with others to address the issues of carbon emissions or environmental impact.

A sustainable building material will meet as many of the above criteria as possible. Its performance will impact on each layer of the building components:

HEMP BUILDING MATERIALS

Materials used in construction manufactured from industrial hemp utilise the two components of the hemp stem; the outer bast fibres and the inner core particles.

The fibres are used to produce a fibre insulation matting as either batts or rolls. This material is installed between timber structural elements to provide insulation.

The inner core particles also referred to as hurds or shivs are combined with a hydroscopic binder to form what is commonly called hempcrete. These are utilised to provide an envelope around a structural frame. It can be manually cast or spray applied on site or can be preformed into blocks, or panels offsite.

BUILDING LAYERS

Site -
The main activities associated with the installation of hemp building materials are not dangerous during manual application. Sprayed application has limited risks if not carried out correctly by untrained personnel. Protective clothing is recommended when necessary.

Structure -
Structural frameworks of a building can be constructed from bamboo, concrete, masonry, steel or timber.

Skin -
All external surfaces should be vapour permeable but waterproof.

Services -
Electrical conduits and water pipes can be installed before or after installation.

Space -
The density of hemp materials is such that the physical volume of material occupies a similar space to existing materials in conventional systems of construction.

Stuff -
Many of the internal fixtures, fittings and finishes of a variety of building types can use hemp-based products.

ORIGIN

Carbon Balance in Manufacture / Transportation / Embodied Energy Use -
The carbon sequestering potential of natural bio-materials is calculated to be around 1.3 - 1.6 metrics tonnes of CO_2 stored for every 1 tonne of dry material harvested including transportation during processing.[1] Local production is possible in a wide range of geographical regions. With greater uptake of the technology the materials will require less transportation. If a combination of hempcrete or hemp fibre and a timber frame is used as the primary elements, the complete envelope might be considered carbon negative due to the storage of carbon by both materials.

Agricultural Production -
Hemp production is suited to regions of existing tillage activity, providing an ideal break crop for other crops production and an improved soil condition. The transition to organic production can be assisted by the growing of this crop.

Safe Employment - Non-Hazardous / Toxic -
Those working with hemp materials are not exposed to harmful or toxic, off-gassing or other chemical emissions during the manufacture or installation of hemp materials. The lime content of some hempcrete binders can cause damage to exposed skin requiring the watering of protective clothing in this situation.

Carbon Sequestering Abilities -
The combination of hemp materials and binders produces lower or in some cases negative emissions compared to fossil based alternatives. Lime based binders reabsorb carbon emitted during manufacture during the lifetime of the material.

Low Transport Costs -
In either hempcrete or hemp fibre form hemp building materials are considerably lighter than other masonry materials. This enables greater volumes to be transported with equal energy use. Hemp fibre insulation products are compressed with packaging in a similar manner to other existing fibre insulation materials, reducing bulk during transportation.

Cradle to Cradle Use -
Raw hemp processing produces no waste, as all by products have a value. Unused material can be reused or recycled on site or at a later date in many situations. Any waste materials not used are biodegradable.

Global to Local Economy Adaptability -
Hemp materials can be produced in both low tech or high tech environments in the developed or developing worlds. The range of applications of the material to provide low energy, climatic control of an interior environment means it can be applied to virtually any building use or type.

INSTALLATION

Net Zero Construction -
The energy performance of hemp based materials provides the ideal structural envelope to include the use of energy producing installations such as solar water heating, heat pumps or photovoltaic panels. The combined carbon footprint and energy production from such buildings easily achieves this description of net zero.

Non-Toxic -
Refer to ORIGIN - 'Safe Employment - Non-Hazardous / Toxic'

Adaptable to Varied Application Techniques -
Hemp fibre insulation is installed in a similar manner to other fibre insulation materials such as glass fibre, rock wool or sheeps wool. The original method of casting hempcrete around a bamboo or timber framework is possible in all levels of sophistication of building techniques. Hemp blocks or bricks are also installed in the same manner as traditional materials. Precast panels can be manufactured using monolithic wall systems or in multiple layers or combinations of materials. Sprayed hempcrete can be applied to new or existing buildings. Hemp materials can be applied to new or old buildings.

Adaptable to Varied Design Formats -
The majority of usage of what is termed hempcrete is for a non load bearing situation and so is applied as an insulating envelope. This can be in cold, hot, arid, damp or tropical climates surrounding a suitable structure for the region. A complete envelope can be achieved by application to the floors, walls and roof of a building. Certain material compositions can achieve load bearing potential especially in single storey designs.

BEHAVIOUR

Vapour Permeable and Mould Resistant -
The ability of a hempcrete or hemp fibre material to be vapour permeable reduces the risk of high levels of moisture condensing on the inner surface, the additional aspect of mould resistance of the lime element of most hempcrete binders also removes the occurrence of 'sick building syndrome'.

Uniform Envelope Layer without Thermal Bridging -
Hempcrete used as a monolithic cast or sprayed layer creates a uniformity of performance without gaps or variations of thickness to provide, once internal and external finishes are applied, an air tight envelope.

Predictable Regulation of Indoor Humidity -
The microscopic structure of the hemp and binders provide a buffering of hygroscopic behaviour throughout the uniform mass of hempcrete. This is controlled by the combination of Relative Humidity.

Buffering Temperature and Thermal Extremes -
Current definitions of energy performance for materials or buildings are focussed on measurements of temperature transference only. In the case of porous materials such as hempcrete this in a function of temperature AND water content. Vapour Active materials respond to changes in environmental conditions, absorbing and desorbing moisture, thus acting as a hygric buffer. They also absorb and desorb thermal energy, acting as a thermal buffer. They have the potential of elevated thermal buffering through the action of heat of sorption, described as 'virtual thermal mass' (see below) [2].

MEASUREMENT

Thermal Mass -
In addition to the actual thermal mass of hemp-lime, phase changes from condensation/evaporation, peculiar pore connectivity in hemp hurd/shiv suggests that evaporation/condensation effects occur outside of normally expected temperature range due to partial pressure differences. This results in elevated thermal mass effects.

Insulation materials such as closed cell insulation are not 'vapour active' they do not respond to changes in environmental conditions. They have a low thermal mass.

Effusivity -
The surface of a material will expel heat stored within it in a variety of transfer mechanisms, including conductivity, convection and radiation, as well as contact resistance between the sensor and sample. The interaction between the surface heat of a wall and an occupants body heat defines the sense of comfort experienced. A fast reaction such as hempcrete or hemp plaster provides reduces energy needed to achieve comfort.

Virtual Thermal Mass -
This performance behaviour of hempcrete is provided by the latent heat of condensation of water causing a temperature change caused by phase change.

Carbon Sequestration -
Hemp cellulose stores carbon and can be considered carbon negative. The binders for fibre insulation hempcrete or hemp plaster are carbon positive. Those created with clays have very low embedded carbon other than the exposure of the material to air or from excavation and transport. While those originating from calcined materials such as lime have a heavier impact, Calcium oxide reabsorbs Carbon dioxide during it's lifetime reconverting to Calcium carbonate. This behaviour allows for the majority of the carbon emission to originate only from the heating of the minerals. When the carbon emissions of the hempcrete binder are subtracted from the carbon sequestration of the hemp cellulose the result is calculated as remaining carbon negative.

MAINTENANCE

It is essential to maintain the vapour permeability of the envelope. This entails the use of vapour porous paints or finishes internally or externally. Externally the use of silica based paints ensures the correct moisture management and long term durability. Internally non VOC emitting paints are recommended, walls can be painted with a variety of natural paints in a conventional manner.

Able to be Repaired and Replaced -
The density and hardness of hempcrete is such that any excavations or channeling can be carried out with minimum energy and as with any plastered surface will need to be repaired for visual satisfaction. Any patching or replacement is easily achieved.

Future Proofed -
The use of hempcrete has many benefits to prevent environmental damage. Being lightweight and having a slight flexibility of structure, hemp buildings are less liable to be affected by subsidence. The materials, if correctly installed do not deform over time due to gravity thereby maintaining the position and volume in a structure continuing the integrity of the envelope. It is expected that a hemp building will have a lifetime of a minimum of 100 years. The materials being completely recyclable or biodegradable.

Example of potential diagram for Performance Cycle Analysis of hempcrete.

(To provide a more complete and definitive description of the grading of each quality, the relative value components would need to be explained in detail.)

SUMMARY

The **International Hemp Building Association** holds the opinion that the current method of measuring the energy performance of building materials is flawed. It neither correctly addresses the behaviour of natural materials or accesses the overall impact of the production or usage of the materials. This is especially relevant to the present focus on 'R' or 'U' values currently used to evaluate a building or materials performance.

In order to correctly compare construction materials for the energy performance or environmental impact they might have, it is necessary to use a range of qualities or performance. The relationship of these values to any action to address climate change is of great importance as the construction sector is estimated to contribute 38% of harmful carbon emissions [3] affecting global climate chaos.

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