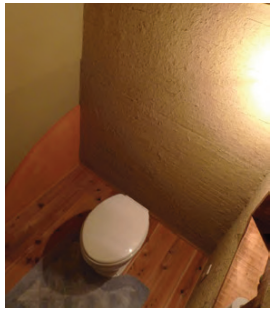
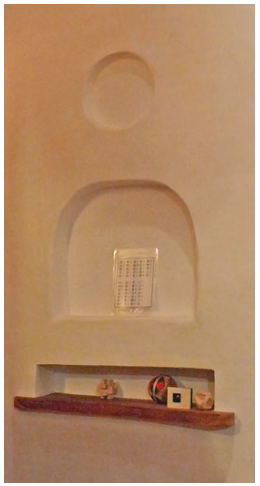
Mixing local earth and straw fibers...

...and application of earthen plaster

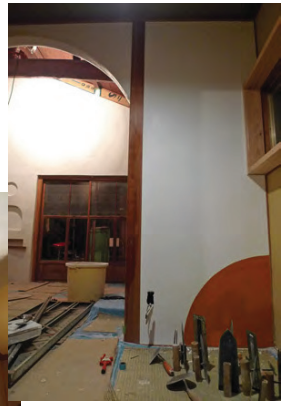
Base coat earthen plaster over wood lath



Composting toilet



Niche



Shikkui Finish

The use of old tatami mats as infill insulation also holds tremendous promise in Japan.

One could argue that using discarded tatami or inexpensive straw mixed with clay instead of costly straw bales is closer in spirit to our historic Nebraskan straw bale ancestors. In any case, the author expects in Japan the number of new homes using light straw clay or old tatami infill will surpass the number of new straw bale homes within the next five years.

Kyle works as a builder, consultant, researcher and educator specializing in natural building materials such as straw bale, light straw clay and natural plasters. He has a PhD in Bioresource Sciences from Nihon University where he researched the hygrothermal environment of straw bale walls in Japan and building practices to control moisture. http://holzhueter.blogspot.com, http://japaneseplastering.blogspot.com

Building with Hempcrete (hemp-lime): Essential Tips for the Beginner (Part 1)

by Alex Sparrow

Disclaimer: The author provides this overview of hempcrete construction in the spirit of advancing the knowledge and skills of people wanting to use the material. This article does not constitute a full training programme in the use of hempcrete and it remains the responsibility of designers and builders to detail and specify materials for their own buildings, and to ensure that contractors are fully trained. The author can accept no liability for the actions of his readers.

Introduction

Following on from Tom Woolley's article in the last issue of TLS, I thought some practical tips on building with hemp-lime would be a natural progression (if you'll forgive the pun). My business partner William Stanwix and I run a company called Hemp-LimeConstruct which has been building commercially with hempcrete in the UK for 6 years now, both in new-build (from small extensions, of domestic houses to large community buildings) and in the restoration and retro-fit of traditional and historic buildings. We have learned a great deal along the way, and now provide consultancy and training services to others wishing to use hempcrete; self-builders, construction industry contractors and architects alike. The desire to disseminate information to others has culminated in our forthcoming book *The Hempcrete Book: Designing and building with hemp-lime* which is to be published later this year.

A new build hempcrete house under construction

In this two-part article I'd like to share some key tips and important "dos and don'ts" when using the material in construction. In this, the first part, after discussing terminology and the basics of using hempcrete in construction, we will go on to look at the first steps in constructing a hempcrete wall taking us as far as the construction of the structural timber frame. In the next issue of The Last Straw the concluding part will cover key techniques for mixing and placing hempcrete together with essential tips for the drying stage.

Hand-placed hempcrete cast around a central softwood frame

Nomenclature

To start with, let's look at the terminology; there are numerous ways of using hemp in construction and the different methods can sound very similar:

"Hempcrete" or "Hemp-lime": A hemp-lime composite, non-load bearing construction material providing both insulation and thermal mass. The hemp shiv (chopped hemp stalk) forms the majority of the composite, and creates an open matrix structure with a lime (or lime-based) binder coating each particle of shiv and binding them together.

Industrial hemp has been grown in the UK since 1993

Bales of hemp shiv waiting to be used on site

"Lime-hemp plasters": A lime plaster (either based on fat lime putty- or hydraulic lime-sand mix) with the addition of a small proportion of hemp fibres (usually the strong bast fibres – the long fibres which wrap around the outside of the stem - but the woody hemp shiv can also be used). The addition of the hemp provides a little insulation to the finished plaster, improves its hygroscopicity, and also adds strength in tension (in the same way that hair does in traditional lime plastering), allowing the application of thicker layers of plaster, and preventing shrinkage cracking. Hygroscopicity refers to a material's ability to absorb moisture from the air during periods of high humidity, thus maintaining healthy indoor air within the building.

"Hemp fibre insulation": A manufactured insulation quilt, or batt, produced from the strong bast fibres of the hemp plant. In comparison to synthetic insulations, hemp fibre, like other natural fibre insulations (e.g. sheep wool or wood fibre), is vapour permeable and hygroscopic and keeps its shape (and thus its insulation value!) even after repeated exposure to moisture. These insulations are always combined with a binder (usually polyester) during the manufacturing process and, since they contain no lime to provide these functions, require chemical treatment for fire and pest resistance.

Various other innovative uses of hemp are gradually appearing on the market, such as hemp fibre underlay felts, hemp fibre board materials and clay-hemp load bearing bricks. A type of hempcrete which uses clay as the binder is also viable, although this is not sufficiently weather resistant for use in external walls.

The smooth, but 'open' surface of a hand-placed hempcrete wall

The 'basics'

This article will focus only on cast in situ hemp-lime, commonly known as hempcrete, a vapour permeable (or 'breathable') hygroscopic non-load bearing material with exceptional thermal performance. In new buildings, hempcrete is usually cast on site, in shuttering (formwork) around a structural timber frame, but it can also be cast against existing masonry walls as a retro-fit insulation for solid walls.

Pre-cast hempcrete blocks, laid in a lime mortar, are also used and for large scale applications these blocks, or pre-cast hempcrete composite panels, are a sensible option, as both methods eliminate the problem of variable drying times on site which can have an impact on the schedule of the build.

A small hempcrete design studio, with green roof and reclaimed brick plinth

When building with cast in situ hempcrete drying times should be kept in the forefront of your mind from the outset, since this is major cause of delays before finishes can be applied, and thus the major cause of disagreements with clients and/or main-contractors. The drying time can be dramatically reduced through the choice of materials, through skilful mixing and placing of the material, and through sensible "drying management" on site, so it is important to be aware of this from the start; both to ensure good construction practice and to manage the expectations of everyone involved from the very start of the project.

When casting hempcrete on site, two main options exist: hand-placing, or spray-applying. In hand placing, the material is mechanically mixed, then transported by hand to the shuttering in large tubs (it is not very heavy), where it is placed by hand. In spraying, the mixing, delivery and application is all mechanised. We have tried both, and we prefer hand-placing for a number of reasons.

Hand-placing is the more accessible and low-tech approach. Hempcrete sprayers are not readily available to hire, and they cost money to buy, store, transport, clean and repair. In our experience sprayers produce a more binder-rich hempcrete, adding to the density of the material and its embodied carbon (although the finished material is still a net carbon sink – locking up more CO2 for the lifetime of the building than was used in its construction). The process of spraying requires the use of a vapour permeable plaster carrier board as permanent shuttering on one side of the wall (to spray against) which introduces another highly processed, high embodied energy material to the wall build up, and adds another cost.

While spraying reduces the number of people on site (3 people, as opposed to 5 or 6, for an average sized house; around 70-80m3 of hempcrete), it doesn't reduce the build time on a project of this size. Spraying is a noisy, messy business, requiring heavy duty protective masks to be worn, and somehow detracts from the sociable experience which can be had when hand-placing hempcrete in a larger team. The action of spraying also means that significant amount of the material ends up on the floor (as much as 10-20% wastage) although this can be mitigated by collecting it up and using it to cast a hempcrete floor slab if one is required. Lastly the surface of a sprayed hempcrete wall is uneven and unconsolidated, (in comparison to the flat even surface of a hand cast wall once the shuttering is removed. This means that more plaster is taken up by the wall in the basecoat, adding to the cost of finishes. Nevertheless, when casting larger buildings – above 120m3 of hempcrete say – or when applying hempcrete to an existing masonry wall, the efficiencies achieved mean that spray-application really comes into its own.

Hand-placed hempcrete construction

When hand-placing hempcrete the key dos and don'ts relate to the mixing and placing of the material, and we will explore these in the 2nd part of this article, however there are also mistakes to be avoided during the initial stages of the work.

Laying pre-cast hempcrete blocks

There are many possible options when designing a hempcrete building, too numerous to discuss here, but it is worth noting that hempcrete buildings are usually much more successful when detailed by someone who understands the material fully (preferably someone who has first-hand experience building with it). There are also advantages when the designer is knowledgeable about the use of natural materials generally, and understands the way that natural buildings work holistically, with each building element working together to ensure airtightness, thermal performance and effective moisture management. Since hempcrete can be used in walls, floor slabs, roof insulation and ceilings, it is possible to cast the whole

Spray-applied hempcrete around a central softwood frame

building envelope in one piece, thus taking full advantage of the exceptional thermal performance and airtightness that the material offers. The greatest challenges for building designers are the insulation of the plinth at the bottom of the hempcrete wall, and effective detailing at the eaves if a different material is to be used for the roof insulation.

A hempcrete wall is usually constructed to a thickness of 300-350mm (12-14 inches) which, depending on the exact binder used, achieves a U-value of around 0.2 W/m2K at 300mm (12 inches) to 0.17 W/m2K at 350mm (14 inches). However it is worth remembering that a) the actual U-value achieved depends on the skill of the person placing the hempcrete on site, and b) the thermal performance of hempcrete exceeds what is expected for such U-values due to the interaction of insulation and thermal mass in the same material.

Plinth

The standard basic construction detail for walls is a masonry plinth at the base of the wall, to keep the hempcrete at least 250mm (10 inches) off the ground. This ensures that the plant aggregate in the hempcrete is not exposed to standing ground water or excessive splash back from rain. On top of the plinth sits the sole plate of the timber frame which is usually placed centrally in the wall. A rubberised damp proof course (DPC) is usually specified by building control authorities to sit on the plinth underneath the sole plate (although if your plinth is built with vapour permeable blocks and mortar, or a free draining construction, then this DPC is not strictly necessary). Thought needs to be given to insulating the plinth otherwise you will have a huge thermal bridge running around your building at the base of the wall. This is usually achieved by the use of load bearing thermal blocks, such as recycled glass foam blocks, or by a loose fill natural insulation material such as light expanded clay aggregate (LECA) in a cavity construction. Note that the latter would involve moving the frame to one side of the plinth rather than placing it centrally.

A two storey hempcrete extension under construction, showing hempcrete walls and roof insulation

Hempcrete apartments at Tomorrow's Garden City, Letchworth, UK (built by North Hertfordshire Homes and Rowan Homes)

Timber frame

The timber frame acts as a support for the hempcrete (until it dries fully) and takes all the structural loads of the building, so it should be specified by a suitably experienced or qualified person, and signed off by the relevant building control authority. In a hempcrete building (with a frame placed centrally in the wall) the timbers can be untreated softwood, since the vapour permeability prevents excess moisture being held against the timbers, and the surrounding lime prevents rotting, and keeps the timbers safe from insect attack (nothing eats lime!). The presence of the hempcrete - which, while not load bearing, is very strong in tension - also allows a reduction in timbers compared to a standard structural timber frame. In particular hempcrete provides a huge amount of racking strength to the frame and reduces the need for diagonal bracing (though you still need to fix temporary diagonal braces to frame before the hempcrete is placed). It also eliminates the need for horizontal noggins, as the hempcrete around the vertical studs provides complete stiffness. It is actually important to leave out all horizontal timbers unless absolutely unavoidable, since it is difficult to place hempcrete around them evenly.

The vertical studs of the timber frame extend up from the sole plate to support the wall plate around the top of the wall and intermediate plates, as necessary, to

take floor joists in buildings of multiple floors. It is usual to construct a roof frame which includes a good overhang at the eaves to give maximum protection to the wall, although examples exist in the UK where hempcrete buildings have been built with little or no overhang, using proprietary formulated lime renders which are hydrophobic while remaining vapour permeable. The framework for windows and doors is either constructed as part of the frame or offset from it.

Services are run in the frame prior to casting the hempcrete

Fixings and Services

Due to the extreme alkali environment inside the hemp-lime wall, all fixings within the wall should be of stainless steel (screws or nails), or hot dip galvanized (nails). Cheaper galvanized fixings (such as electricity back boxes) are acceptable for non-structural fixings only, as they will corrode to some extent where they are in contact with the hemp-lime. Where other structural fixings are required, that are not available in stainless or hot dip galvanized versions, these can be painted to protect them before the hempcrete is cast.

Harvesting hemp

Electrical installations running through hempcrete need to be run in conduit (either PVC or stainless steel) since it is surrounded by an insulating material. The usual way is to clip this into the frame before the hempcrete is cast, with back boxes positioned on noggins at the face of the wall, so shuttering boards can be run straight across the front of them. However it is easy to chase services into hempcrete once it has hardened using a disc cutter.

Water and gas services can, if absolutely necessary, be run within (or more usually across) the hempcrete wall, taking care to protect any copper piping from the lime by running it inside a PVC conduit sheath, and remembering that any joints in pipes should be positioned outside the cast material in case access is required at a later date. Again, such services can be positioned before casting, or drilled through afterwards (as long as you know the exact position of the timber frame inside the wall!).

Once the hempcrete has hardened, light to medium duty fixings can be made directly into the hempcrete wall, but for areas where heavy duty fixings will be required (e.g. for high level kitchen cabinets), consider designing in a timber attached to the frame, so that you know a strong fixing can be found at a given height around the room. Instead of fixing shelves to the wall afterwards, consider designing in recessed alcoves for shelving which can be formed with the shuttering and cast in the wall during construction.

The concluding part of this article will feature in the next issue of The Last Straw (TLS65); in which we will cover the fixing of shuttering around the timber frame, mixing and placing hempcrete, and good drying management after casting is complete.

The issues and methods outlined above are discussed in more detail in William Stanwix and Alex Sparrow's forthcoming book: The Hempcrete Book: Designing and building with hemp-lime. The book is in three parts: a

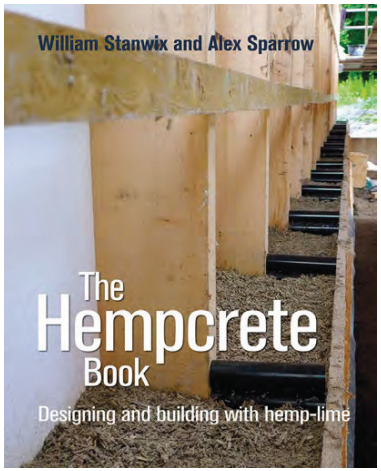
Hempcrete apartments at Tomorrow's Garden City, Letchworth, UK (built by North Hertfordshire Homes and Rowan Homes)

Interior of a self-build hempcrete house

Hempcrete apartments at Tomorrow's Garden City, Letchworth, UK (built by North Hertfordshire Homes and Rowan Homes)

A large department store constructed with pre-cast hempcrete panels Elsmere Port, UK (built by Marks and Spencers)

discussion of the underlying principles of hempcrete building; a full practical construction manual; and a section on detailing and wider design considerations for architects and other building designers.



The publication dates are 9th October (UK) and 1st November (USA). More information can be found at http://www.greenbooks.co.uk/the-hempcrete-book

TLS readers can buy 'The Hempcrete Book' at 30% off either hardback or paperback edition. Just go to www.ipgbook.com/hempcrete and use the code HEMPFALL14 by the end of October.

Hemp-LimeConstruct can be contacted through their website at www.ukhempcrete.com, or via twitter: @ UKHempcrete and @hempcretebook.

A video showing hempcrete being mixed in a drum mixer is available at: http://www.youtube.com/watch?v=w1FupaK-rvM

See also:

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Daly, P., Ronchetti, P. and Woolley, T. (2013) Hemp Lime Bio-composite as a Building Material in Irish Construction. Environmental Protection Agency Ireland: online only. http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=202

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Light Clay-Straw Mountain Home

by Jeff Ruppert

Hal Brill and Allison Elliot created a beautiful living space in the mountains of Western Colorado through a hands-on approach and taking their time with major decisions.

6,000 ft (1,830 m) above sea level and at the top of a newer subdivision on the outskirts of Paonia, Colorado the Brill/Elliot home is on a two and a half acre parcel with breath-taking views of the West Elk Mountains and 11,400 ft Mount Lamborn. It is a very custom habitat for two people who value living lightly on the earth. Their approach has allowed them to combine newer technology with a warm, welcoming feel. Their home costs nothing to operate and exemplifies modest, customized living through natural building.

The Construction Process

House construction commenced in 2010 and was completed in 2012. The first phase of the project consisted of building the garage/office space as a staging area for the house construction the following year. Instead of doing everything at once Hal and Allison took their time, as they did during the design process, making thoughtful decisions at every step.

Both the garage and house are dug into a hillside, meaning there are tall retaining walls on the Northern side of the structure. Instead of using regular concrete foundation walls they chose Faswall blocks, which are a combination of wood chips and cement, incorporating rock wool insulation into each block. The block cores are filled with concrete and reinforcing to create a substantial wall capable of withstanding normal soil and water pressures below grade.