

# HEMP LIME

## An introduction to low-impact building materials

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This Information Paper provides a broad view of the benefits and limitations of non-loadbearing hemp lime walls for those considering their use in construction projects.

Hemp lime is a low-carbon building material with good insulation properties and robustness. It is particularly suited to projects where the design calls for a rendered or rain-screened external finish, good insulation and minimal thermal bridges. It is most commonly used in conjunction with timber frames, but can act as a non-structural walling element for a variety of construction types, including lining masonry walls.

This is one in a series of five Information Papers and parallel case studies on low-impact building materials. The others cover straw bale, unfired clay masonry, cross-laminated timber and natural fibre insulation.

Hemp has been used for millennia in a wide range of applications, from sacks and rope through to paper and oil. It was one of the first domesticated plants (originally in China) and was a sufficiently important material that it was taken to America in seed form by the Pilgrim Fathers.

Industrial hemp is now grown again in Europe and North America, having been banned for a period due to the connection with cannabis (industrial hemp has very little active drug). It can be grown in many temperate climates, and in the northern hemisphere is usually planted in April and harvested at the end of August. Hemp is a fast-growing plant, reaching a height of 3–4 m at harvest with no need for pesticides or herbicides after planting. Once harvested, cut hemp is sometimes allowed to dry initially in the field before the shiv (the woody central core) is separated from the outer fibres. The fibres are extracted for a variety of uses (eg textiles, composites). After fibre extraction, the shiv is shredded into chips, graded and stored until required for construction.



Figure 1: The Renewable House on the Innovation Park at BRE near Watford, Herts, constructed with hemp lime walls (Courtesy of Lime Technology)

When used in situ, hemp lime is applied as a non-structural external infill; it is typically cast inside formwork. Alternatively, it can be spray-applied against a lining board. Both methods result in a homogeneous solid wall construction encapsulating a timber frame that has good insulation properties and good airtightness, and avoids thermal bridges.

Hemp lime is most commonly a mix of renewably sourced hemp shiv, a specially formulated lime binder and water. Hydraulic lime (as opposed to hydrated lime), which is able to set and harden under water, has been used in place of formulated binders, with the mix created independently, although performance can be less reliable as a result. A proportion of cement is usually added to formulated commercial binders to aid the early age performance. The quantity of cement used varies between producers and in many cases has not been disclosed. However, the addition of pozzolanic material such as pulverised-fuel ash in many formulated limes minimises the use of cement.

**Box 1: Why specify hemp lime?****Advantages**

- Avoids thermal bridging and provides good airtightness with simple detailing
- Good thermal insulation properties offering some thermal mass
- Lightweight material with simple construction details and processes
- Light weight reduces load on foundations, so less need for materials with high embodied energy (eg concrete)
- Renewable material that stores carbon throughout life of material
- Vapour-permeable construction envelope

**Limitations**

- High level of understanding of specific product required by designers and contractors
- Onsite construction more suited to warmer months (drying times reduced), although can be successfully used during winter months with protection
- Requires time and shelter during drying on site before finishes can be applied
- Use limited to above damp-proof course or equivalent level

Quicklime (calcium oxide) is initially obtained by heating sources of calcium carbonate (such as limestone) in kilns, a process that releases CO<sub>2</sub>. The quicklime is then hydrated (slaked) using water to form hydrated lime (calcium hydroxide), a product widely used in construction and other industries. Construction uses for hydrated lime include soil stabilisation, mortar binders and renders. Once dried, calcium hydroxide slowly hardens by reacting (carbonating) with CO<sub>2</sub> to form calcium carbonate. The high alkalinity of lime has mild anti-bacterial properties that reduce the risk of mould and fungal growth. Calcium hydroxide forms the basis of many proprietary formulated binders used for hemp lime; other ingredients include cement and pozzolanic additives.

Like hemp, lime has been used for centuries for a wide range of applications: for construction, primarily in mortars and renders, together with being the antiseptic and antibacterial agent used in traditional whitewashing of houses. The hemp shiv forms the lightweight bio-aggregate, with the formulated lime as binding agent and the water initially providing workability and hydration of the binder. The components are combined in pre-bagged proportions (for walls typically 1 part hemp to 1.5–2 parts lime) to create a mixture similar to ‘damp muesli’ in appearance (Figure 2). It is important to control carefully the quantity of water and methodology of mixing to deliver acceptable placement performance and drying times. The material can be overcompressed with immoderate tamping, but it is important to ensure that formwork is uniformly fitted. Spraying hemp lime requires specially adapted equipment and a high level of skill to deliver a consistent replacement process. The mix has to dry to reach optimal thermal resistance, but protected by lime binder and a render (or other vapour-permeable external finish) it provides long-term performance without deterioration.



Figure 2: Freshly placed hemp lime  
(Courtesy of University of Bath)

Hemp lime should not be used below ground level, and must be detailed to avoid rising moisture (eg using an impermeable membrane) and with consideration for how it can be shuttered and formed on site (Figures 3 and 4). The shuttering can be held in place with long screws back to the frame with the resultant holes refilled when the shuttering is removed after around 24 h (Figures 5 and 6). Drying times depend on a variety of factors, including weather conditions and the finishing system. Some wall systems use vapour-permeable permanent sheathing on the internal face. While drying, hemp lime should be protected from the weather, although free movement of air around it will significantly aid drying times. If the hemp lime does become lightly rewetted during drying out, no permanent harm is done but additional time will be required for further drying.

This Information Paper deals primarily with hemp lime as a wet mix applied on site, but it can also be used in prefabricated panellised construction. The main benefits of a prefabricated approach are delivering offsite pre-dried material and reduced onsite construction times.

Hemp lime’s flexibility of use also allows it to be deployed in a number of other guises within construction. Replacing poorly insulated composite external walls while retaining the frame of the building can provide a valuable option in refurbishment. This can be achieved either with in situ placement or using pre-cast panels.

Hemp lime blocks can also be manufactured. However, the higher binder content required to achieve robust blocks means that the thermal performance is not as good and the cost is increased. Good airtightness and thermal performance are reliant on good build quality, so workmanship is particularly important when specifying blocks.

**Box 2: Typical properties of hemp lime**

As hemp lime is a natural product, performance can vary slightly, but commercial hemp lime wall systems tend to achieve:

- dry density: 270–330 kg/m<sup>3</sup>
- thermal conductivity: 0.07–0.09 W/mK  
(typical U-value at 300 mm = 0.21 W/m<sup>2</sup>K)
- compressive strength: 0.1–0.2 N/mm<sup>2</sup>

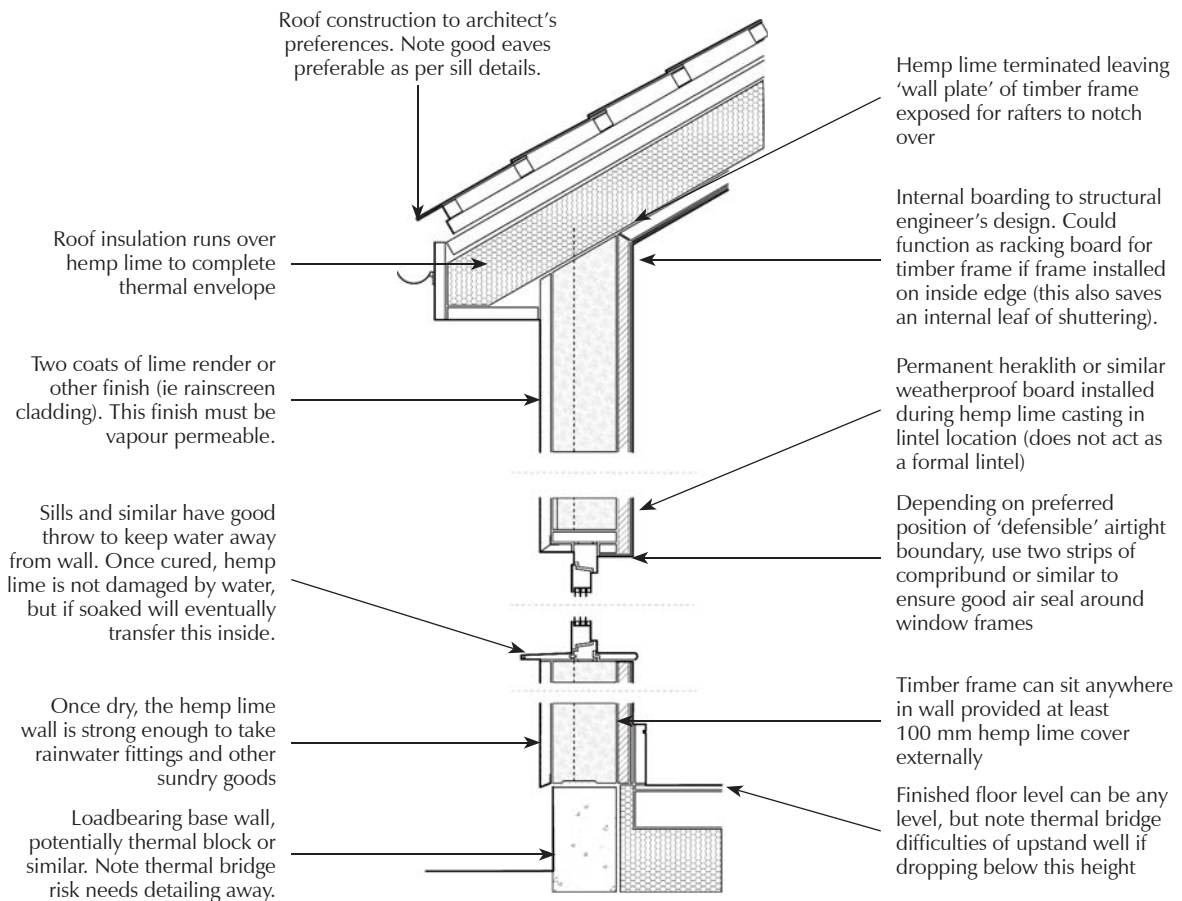
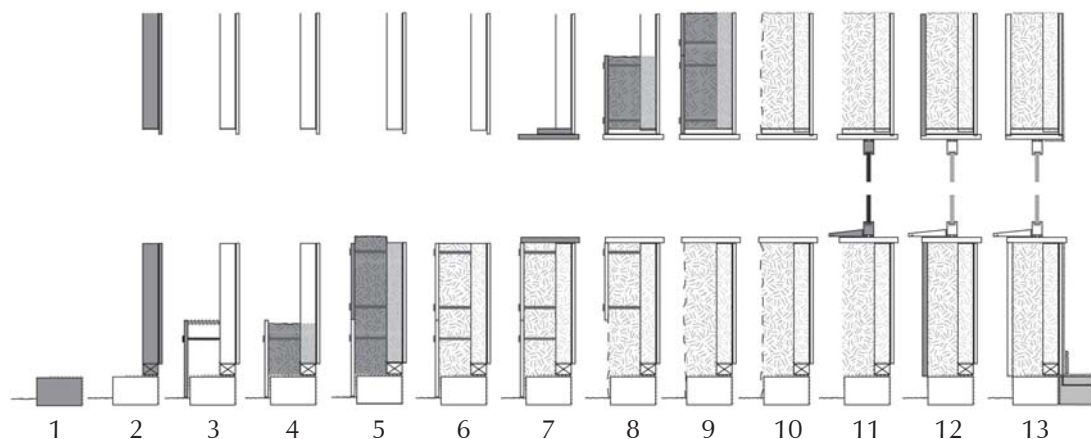


Figure 3: Section detailing of an example hemp lime wall construction



1. Groundwork completed with damp-proof membrane lapped over loadbearing wall footing. Thermal bridging design detail required for this wall footing.
2. Timber to structural engineer's design installed.
3. Damp-proof course fitted and lapped up frame. First of shuttering fitted and screwed back to frame. Shuttering braced with temporary timbers.
4. Shuttering filled with hemp lime mix and lightly tamped down; tamping slightly harder in corners and edges.
5. Second level of shuttering fitted and overfilled with hemp lime to above sill line.
6. Hemp lime cut (once touch-dry) to provide flat finish to underside of sill.
7. Shuttering for opening fitted.
8. Shuttering and filling with hemp lime continues. Shuttering lower down removed and re-used after 24 h drying time.
9. Shuttering and filling with hemp lime continues. Where shuttering is removed, screw holes are filled with hemp lime mix and wall is protected for rain/water as it dries.
10. Once wall complete and shuttering removed, hemp lime mix left to dry for 4–8 weeks depending on weather and temperature.
11. Once largely dry, windows can be installed. These can fix to dry hemp lime or, if fitted sooner, back to timber-frame elements.
12. Lime render (or other vapour-permeable finish) added to protect hemp lime external face.
13. Internal (ideally vapour-permeable) finishes applied.

Figure 4: Construction sequence for an example hemp lime timber-frame wall (with hemp lime cast on site inside formwork)

On site, dry hemp lime can be worked using hand tools (including wood saws), as with lightweight aircrete blocks. Excess product material can be reintroduced in controlled proportions to future mixes, giving the possibility of zero site waste for the product.

Once dried, hemp lime needs no unusual protection from the elements although, as with any solid wall construction, long-term exposure can force dampness through the width of the wall. Hemp lime should be used with an external vapour-permeable finish such as lime render (Figure 7) or rainscreen cladding, and it should be detailed with extended drips to sills, parapets etc. The sill of the window can be addressed by overfilling the hemp lime and then cutting back just prior to installation of the window, as this ensures that there is no material movement gap between the wall and windowsill (Figure 8). Preferably, however, windows and doors are fixed directly to the timber frame. All fixings in contact with hemp lime should be corrosion resistant (eg stainless steel or polymer).

It is important that all finishes remain vapour permeable. If they do not, trapped moisture might eventually build up to affect the thermal performance and, if untreated, will potentially degrade the hemp shiv and/or timber frame. If this occurs reinstating a vapour-permeable finish may arrest the problem, although if damage becomes extensive the wall will need more substantial repair or replacement.

Localised damage, repairs or alterations can be patched with more hemp lime, installed as appropriate. Any added hemp lime should bond to existing hemp lime sufficiently for localised patching, but larger connections may require appropriate connection details and/or pins.

Some hemp lime products have British Board of Agrément (BBA) certification. Nationwide local authority building control approval for buildings up to 12 m high is subject to design limitations. If using other sources of hemp lime and/or different construction details, the appropriate building/development control body should be contacted before detailed design to ensure acceptability.

### Box 3: Carbon storage

The embodied carbon of hemp lime products is low relative to many other construction materials. As with all plant-based materials, carbon is stored during plant growth and continues to be stored through its use as a building material. At the end of its life, it can either be remixed with new material, used as biomass or otherwise sawn up to be returned to the soil; at this point it slowly releases the carbon through decomposition while also returning other nutrients to the soil.

## FURTHER READING AND SOURCES OF INFORMATION\*

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\* All URLs accessed October 2011. The publisher accepts no responsibility for the persistence or accuracy of URLs referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.



Figure 5: Shuttering in place ready to receive hemp lime  
(Courtesy of Glenn Howells)



Figure 6: Tamping hemp lime into shutters  
(Courtesy of Mike Lawrence, University of Bath)



Figure 7: Applying a vapour-permeable render by spraying  
(Courtesy of Mike Lawrence, University of Bath)



Figure 8: Completed wall ready for window frames and sills to be fitted  
(Courtesy of Glenn Howells)



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