HEMP LIME CONSTRUCTION
A guide to building with hemp lime composites

Rachel Bevan and Tom Woolley
With contributions by Ian Pritchett, Ralph Carpenter, Peter Walker and Mike Duckett
HEMP LIME CONSTRUCTION

A guide to building with hemp lime composites

Rachel Bevan and Tom Woolley
HEMP LIME CONSTRUCTION

A guide to building with hemp lime composites

Rachel Bevan and Tom Woolley

With contributions by Ian Pritchett, Ralph Carpenter, Peter Walker and Mike Duckett
Aston Clinton, Buckinghamshire © Crawford/Radclyffe

Fig 1.1: Seven-storey office building in Clermont Ferrand which uses hemp lime blocks © Lhoist UK Ltd

Fig 1.2: Interior of the Adnams brewery warehouse, Abingdon, Oxfordshire © Lime Technology Ltd

Fig 1.3: Shuttering for hemp lime wall, Aston Clinton, Buckinghamshire © Crawford/Radclyffe

Fig 2.1: Hemp shiv with lime being mixed © Lime Technology Ltd

Fig 2.2: Timber frame and hemp lime infill being tamped by school children. Hemp lime is ‘child’s play’ © Ashley Pettit Architects

Fig 2.3: Hemp lime blocks © Lime Technology Ltd

Fig 2.4: Hemp lime block wall in French office building © Lhoist UK Ltd

Fig 2.5: Hemp lime being sprayed at the Lime Technology Ltd head office building © Lime Technology Ltd

Fig 2.6: Hemp lime infill being used to renovate an historic timber frame house © Marianne Suhr

Fig 2.7: Lime mortar silo Delivery of hemp bales to Hemcore

Fig 3.1: Adnams brewery warehouse general view

Fig 3.2: Adnams brewery warehouse interior

Fig 3.3: Greenlight project, detail of interior

Fig 3.4: Greenlight project general view © Lime Technology Ltd

Fig 3.5: Croxley Green barn conversion © Lime Technology Ltd

Fig 3.6: Pield Heath Avenue, London © Richard Monkhouse

Fig 3.7: Ralph Carpenter’s house, Suffolk

Fig 3.8: Haverhill social housing hemp house and adjoining brick house

Fig 3.9: Lime Technology office at Milton Park, Abingdon

Fig 3.10: Brakspear summerhouse, Worcester

Fig 3.11: Brakspear summerhouse, Worcester (under construction)

Fig 3.12: Trladical exhibition stand, Ecobuild 2007

Fig 3.13: Clay Fields, Elmswell (under construction). Shuttering in place waiting for hemp lime to be sprayed © Riches Hawley Mikhail Architects Ltd

Fig 3.14: House extension, Oxford © Sally Harper

Fig 3.15: Timber frame construction – WISE building, Centre for Alternative Technology

Fig 3.16: Hemp lime being sprayed – WISE building, Centre for Alternative Technology

Fig 4.1: Hemp crop being harvested in Essex © Lime Technology Ltd

Fig 4.2: Kenaf crop in Malaysia

Figs 5.1 to 5.5 © Ralph Carpenter, Modece Architects

Fig 5.1: Cast hemp wall with timber rainscreen

Fig 5.2: Warm roof eaves with hemp lime cast around sloping rafters

Fig 5.3: Solid wall with hemp lime wall cast onto inner face

Fig 5.4: Brick plinth to timber frame wall (with hemp-based slab)

Fig 5.5: Hemp lime slab with joists and boarded floor

Figures 5.6 to 5.10 © Lime Technology Ltd

Fig 5.6: Plan of corner and window jamb with permanent internal shuttering board and timber frame, for spray application of hemp lime

Fig 5.7: Plan of corner and window jamb with hemp lime cast between temporary shuttering boards, timber frame in centre, with rendered outer face

Fig 5.8: Section with timber frame on an internal face and hemp lime sprayed or cast

Fig 5.9: Head of wall with sloping ceiling (Warm Roof) with timber frame on inner face with permanent shuttering
Fig 5.10: Section through wall with timber frame outer face and rainscreen
Fig 5.11: Modcell hemp lime panel, Ecobuild exhibition 2007
Fig 5.12: Spraying in progress © Henry Thompson, The OldBuilders Company
Fig 5.13: Diaphragm wall of chalk, lime and hemp blocks at Adnams brewery under construction
Fig 5.14: Hemp lime insulation cast between rafters © Lime Technology Ltd
Fig 5.15: Hemp lime floor being cast © Henry Thompson, The OldBuilders Company
Fig 5.16: Hemp and lime infill in an historic building © Marianne Suhr
Fig 5.17: Bungalow in Hillingdon, London, with external hemp lime render © Richard Monkhouse
Fig 5.18: Stone building in Châlons-en-Champagne renovated with hemp lime plaster
Fig 5.19: Internal hemp lime plaster in Eardisland, Herefordshire
Fig 5.20: Model of timber frame and hemp © Lime Technology Ltd
Strata wall, Aston Clinton, Buckinghamshire © Crawford/Radclyffe
Fig 6.1: Hemcore horse bedding bale
Fig 6.2: Tradiical hemp bale © Lime Technology Ltd
Fig 6.3: Tradiical mixing plant at Milton Park
Fig 7.1: Timber clad hemp lime wall at the Greenlight project with Ralph Carpenter
Fig 7.2: Mould growth due to inadequate ventilation and insulation in a precast concrete building
Fig 7.3: Effects of humidity
Plastering a hemp wall © Crawford/Radclyffe
Figures 8.1 to 8.9 © Arnaud Evrard
Fig 8.1: Different moisture states of Hemcrete
Fig 8.2: Graph of water content vs. relative humidity
Fig 8.3: Thermal capacity of various materials
Fig 8.4: Temperature profile through Hemcrete
Fig 8.5: Heat flow through various materials
Fig 8.6: Thermal diffusivity of various materials
Fig 8.7: Dampening of diurnal temperature variation at different depths in Tradiical Hemcrete
Fig 8.8: Thermal effusivity of various materials
Fig 8.9: Monitoring of the Lime Technology Ltd head office during April 2007
Limecrete being placed in wall footings at the WISE building © Centre for Alternative Technology
Fig 9.1: Aerial view of WISE building © Centre for Alternative Technology
Fig 10.1: French Regional Government Office multi-storey building (with detail inset) using hemp block infill walls © Lhoist UK Ltd
Fig 11.1: Straw bale house in Putley, Herefordshire
Fig 11.2: York Eco-Depot constructed with Modcell strawbale panels
Fig 11.3: Heraklith boards used for permanent shuttering with hemp lime
Fig 11.4: Hemp loft board © Natural Fibre Technology
Fig 11.5: Breathe hemp insulation in B&Q
3D view of the WISE building at the Centre for Alternative Technology constructed with hemp lime and rammed earth walls © Pat Borer Architect
Clay Fields, Elmswell (under construction) © Riches Hawley Mikhail Architects Ltd
Fig A1.1: Comparison of hemp lime cube and cylinder test response in compression © Peter Walker
Fig A1.2: Hemp lime cylinder test in compression © Peter Walker
Fig A1.3: Stress-strain responses of hemp lime cylinders under compression loading © Peter Walker
Fig A1.4: Results from hemp lime cylinder tests, undertaken at the University of Bath in 2005 (Kioy, 2005) © Peter Walker
Hemp lime wall in a workshop in Ralph Carpenter’s house, unplastered

All illustrations not credited © Tom Woolley.
For far too long, ‘eco’ building has focussed on energy efficiency in use, with super insulated structures, renewable energy and rainwater collection. This is all very well, but such structures have continued to be built from materials with high-embodied energy or toxic production processes such as concrete, steel and plastic. This book sets out a form of building that offers a real alternative to standard cavity wall construction, providing a carbon neutral option that is easy to use, diverse in its application and cost competitive.

I was introduced to hemp lime construction when searching for an alternative to wattle and daub in the repair of my own timber-framed house. Hemp lime was breathable, and therefore compatible with the ancient timber frame, and could be sculpted to shape. It was also far more thermally efficient than the daub, and did not shrink to create gaps around the edge of the panel. I was so impressed by the material, I went on to use hemp lime for a contemporary extension on the same building. In both instances, the material has proved a roaring success.

Whether you require practical information for building in hemp lime, scientific data for further research or simply want to understand the material better, this book is packed full of all the information you could need. I only wish it had been available before I embarked on my own hemp lime building projects.

Marianne Suhr
MRICS, SPAB Lethaby Scholar
The National Non-Food Crops Centre (NNFCC) is the UK’s national centre for renewable materials and technologies. It uses its extensive market knowledge and technical expertise to build supply chains for plant-derived renewable materials so that good ideas become products that people buy. It establishes and explains the economic, environmental and social benefits of non-food crop materials. And it provides evidence and advice to support the development of policy.

The NNFCC is a not-for-profit company which receives grant funding from Defra but is independent of government and of industry. The Centre acts on the evidence and takes care not to promote non-food crop solutions that do not provide real benefits.

The NNFCC is very interested in crop-derived construction materials, which can contribute to sustainable construction issues including: embodied carbon, energy consumption, waste, and providing greater occupier comfort, for example through buffering moisture content. The Centre is working with several companies developing renewable construction materials. It also publishes information including newsletters and factsheets as well as more detailed studies including a recent life cycle analysis of natural fibre insulation materials.

For more information about the NNFCC’s work in the construction field, contact them by:
Email: enquiries@nnfcc.co.uk
Tel: 01904 435182
or visit their website www.nnfcc.co.uk
ACKNOWLEDGEMENTS

Marshall Addidle, Innovation Relay Centre
Iris Anderson, Defra
Laurent Arnaud, ENTPE
Francois Bardout, Lhoist Ltd
Alan Boyd, AB33
Bernard Boyeux, Balthazar et Cotte
Ralph Carpenter, architect, Modece Architects
Professor A De Herde, Université catholique de Louvain, Architecture et Climat
Mike Duckett, managing director, Hemcore Ltd
Dr Arnaud Evrard, Université catholique de Louvain, Architecture et Climat
Steve Goodhew, University of Plymouth
Mike Haynes, Lhoist UK Ltd
John Hobson, Hemcore Ltd
Ian Law, NNFCC
Brian Murphy, Greenspec
Gary Newman, Plant Fibre Technology
Brian Pilkington, University of Plymouth
Ian Pritchett, managing director, Lime Technology Ltd
Simone Pritchett, Lime Technology Ltd
Rhydwen Ranyl, Centre for Alternative Technology
Michel Rizza, Balthazar et Cotte
Ryman Stephen, Defra
John Stewart, Queens University Belfast
Henry Thompson, The OldBuilders Company
Jeremy Tomkinson, NNFCC
Professor Peter Walker, director, BRE Centre in Innovative Construction Materials, and Department of Architecture & Civil Engineering, University of Bath
Gwyn Watkins, Lhoist UK Ltd
David Williams, NNFCC
John Williams, NNFCC
Tim Yates, BRE
and many more people, too numerous to mention
In 2006 we were commissioned by the National Non-Food Crops Centre (NNFCC) to investigate building construction using hemp lime composites and to write a guide to assist those who want to use and specify the materials. A year-long study funded by the Department for Environment, Food and Rural Affairs (Defra) has led to this guide.

In the UK, Europe and globally there is a general acceptance of the need to reduce carbon emissions and energy consumption. Over the past few years there has been growing interest in the concept of low- and zero-carbon buildings and methods of construction that can facilitate this. Even those who deny that climate change is the result of human activities accept that fossil fuels are increasingly scarce and costly and that the impact of using non-renewable resources is unsustainable and likely to damage the environment. To safeguard both people and planet we have to develop alternative strategies for meeting our needs in building construction, transport, infrastructure, food and so on.

1.1 WHAT ARE ZERO-CARBON BUILDINGS?
The general understanding of zero-carbon buildings is that they involve ‘micro-generation’, adding renewable energy equipment like solar panels and wind turbines to buildings. Certainly, UK government policy has focused strongly on this and on reducing waste and water consumption. These ideas can be found in the Code for Sustainable Homes (Department for Communities and Local Government, 2008) and other sustainable building standards that are being applied by public sector bodies. Energy efficiency, in terms of increasing insulation, is a very important part of these policies but there has, until recently, been little concern about the methods and materials that are used to achieve this, as long as energy consumption is reduced.

Recently, greater awareness has developed in which the nature of the materials and methods of building construction are seen as equally important. It seems foolish to use fossil-fuel-based materials to manufacture insulation when we are trying to reduce our consumption of fossil fuels, yet the insulation industry is dominated by products that are petrochemical-based or require a lot of energy to produce. Many of these synthetic products also use highly toxic additives in the form of glues, binders and flame-retardants that can cause pollution.

Brominated flame-retardants are widespread in the natural environment owing to pollution and emissions from manufacturing and buildings. They have been found in worryingly high levels in the blood of volunteers tested by WWF (WWF-UK, 2003) and are causing concern among Inuit communities near the North Pole, who rely on fish that are now contaminated with toxic chemicals associated with synthetic building materials (The Guardian, 2007 [French LCA, 2005]). Demand for natural and non-toxic materials, as an alternative to synthetic products, is growing rapidly as public awareness of green issues has grown.

1.2 SEARCHING FOR ALTERNATIVES
Petrochemical-based synthetic materials do not biodegrade easily and create worrying problems for the future if they end up in landfill. Thus society has begun to look for natural materials that are renewable (ie materials that can be replaced without doing any damage to the environment), consuming minimal fossil fuel energy, and have minimal pollution and health risks. Crop materials like hemp and flax have become significant in the search for such alternatives.
ABOUT THIS BOOK
Hemp lime is a composite construction material that can be used for walls, insulation of roofs and floors and as part of timber-framed buildings. It provides very good thermal and acoustic performance, and offers a genuinely zero-carbon contribution to sustainable construction. Hemp masonry is breathable and is able to absorb and emit moisture, leading to much healthier buildings. Comprehensive guidance on using this novel material for housing and low-rise buildings is given for the first time in this book, which is full of practical information on materials, design and construction. It is fully illustrated and includes case studies and design details, and explains how the use of hemp based material can capture and store carbon dioxide in the fabric of buildings. The guide is the output from a Defra-funded study commissioned by the National Non-Food Crops Centre.

From the Foreword by Marianne Suhr:
“This book is packed full of all the information you could need. I only wish it had been available before I embarked on my own hemp lime building projects”

THE AUTHORS

RACHEL BEVAN is principal architect at Rachel Bevan Architects, based in County Down, Northern Ireland. Her work includes the specification of ecological building materials and the practice has won awards from the Royal Institute of Architects of Ireland and the Royal Society of Ulster Architects.

TOM WOOLLEY is professor of architecture at the Graduate School of the Environment at the Centre for Alternative Technology and an acknowledged expert on natural building and related environmental issues. He is also professor of Sustainable Rural Architecture at the Countryside and Community Research Institute, University of Gloucestershire. He is chairman of the UK Hemp Lime Construction Products Association.