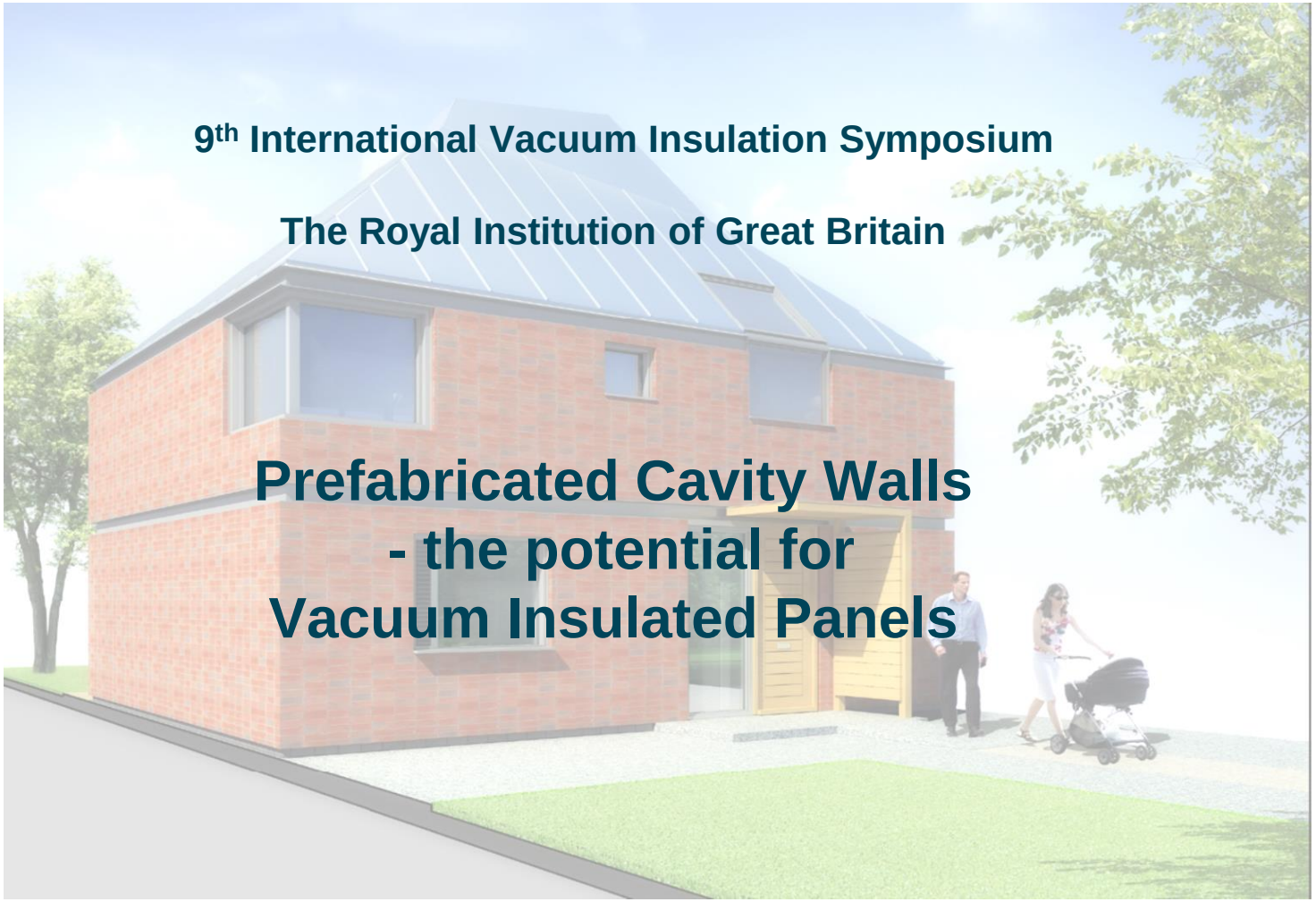


9th International Vacuum Insulation Symposium

The Royal Institution of Great Britain

Prefabricated Cavity Walls - the potential for Vacuum Insulated Panels

Paul Rogatzki

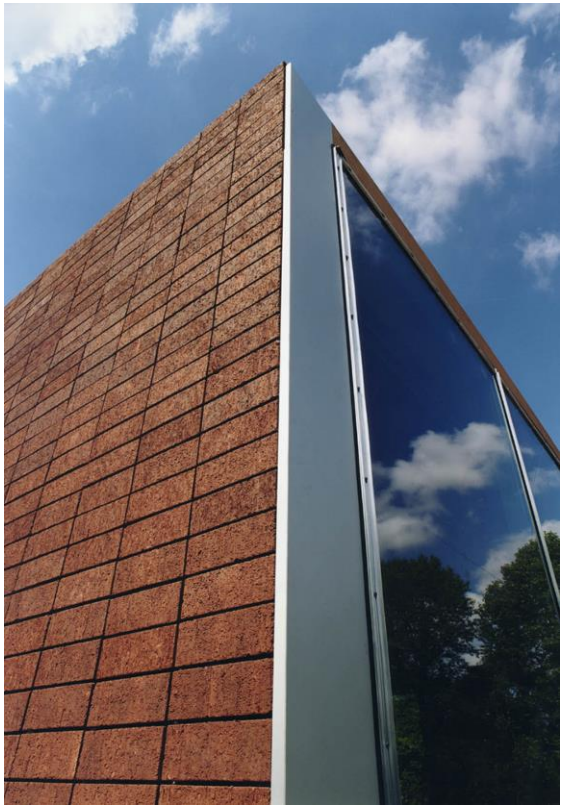
17th September 2009

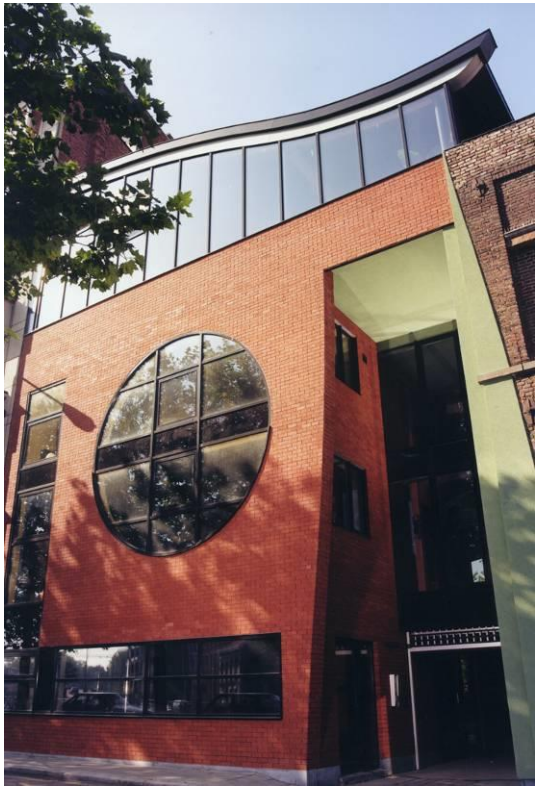
Hanson HEIDELBERGCEMENT Group

Prefabricated cavity walls – the potential for vacuum insulated panels

Developments in thin joint masonry systems in Europe

- Developed over 20 years ago
- Joint thickness can be varied between 3 – 6 mm.
- Joints – Flush / Recessed
- No pointing required
- No mortar in perpends!





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Prefabricated cavity walls – the potential for vacuum insulated panels

Thin joint masonry systems – in situ bricklaying process

- Faster curing times
- Increase rate of gain in strength
- Increased laying rates
- Higher resistance to rain penetration
- Minimal efflorescence

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Prefabricated cavity walls – the potential for vacuum insulated panels

Partners in innovation project 2001 - 2004

This guidance document results from a Partners in Innovation (PII) project sponsored by the DTI, Oxford Brookes University and Industry Stakeholders.

The Industry Stakeholders include Hanson Building Products, Brick Development Association, Ibstock Brick, and Mander Structural Design. The project and this guidance document aim to facilitate the use of thin joint brickwork in the UK.

Introduction

Thin joint brickwork has been used increasingly in Europe; however there are few examples of its use in the UK and use has been inhibited by a lack of design guidance.

New School of Architecture and Planning, University of the West of England

Thin joint stack bonded masonry

Architectural

Thin joint brickwork raises some interesting architectural issues:

- The absence of pointing in thin joint brickwork means that the appearance of the finished wall is unlike that of conventional brickwork. The colour and texture of the brick are enhanced because they are not moderated by the mortar joint.
- The inner and outer leaves of thin joint brickwork do not coordinate and the designer is therefore free to concentrate on assembling a wall from bricks of different shapes and sizes arranged in a variety of patterns.
- Thin joint brickwork makes it easy to manipulate bricks while the wall is being built. It is therefore possible to introduce surface modelling by laying bricks at different angles, or altering the plane of the work by recessing and advancing the face of the brickwork.
- The use of thin joint brickwork gives talented designers the opportunity to be innovative in their use of bricks, creating original and exciting "clay façades".

The detailing of thin joint brickwork generally follows conventional practice:

Dimensions

Thin joint masonry or thin layer masonry in Euro Code 6 is defined as having a maximum joint thickness of 3mm. However this can be difficult to achieve in practice, and a mortar thickness of 4mm is often used. Any size of brick can be used in thin joint brickwork and the brickwork should be set out to the brick plus 3-4mm.

DPCs and Weepholes

Damp-proof courses can be sandwiched between two layers of mortar. Weepholes should be provided at 1.2m centres by omitting the perpends.

01

Guidance Document on the use of

Thin Joint Brickwork

dti
Department of Trade and Industry

BRICK DEVELOPMENT ASSOCIATION

Mander Structural Design

Hanson

OXFORD BROOKES UNIVERSITY

Jointing

Mortar is to be laid at 10mm back from the external face of the brick, and care is needed to avoid mortar to the face of the masonry. Mortar should be applied to ends of bricks before laying them. The mortar should centrally be laid. Initial trial panels should be prepared to ensure sufficient bed and a 10 mm recessed joint to avoid staining the outer face.

Frames

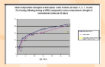
Frames should be used as work proceeds, or a template used to give plus 10mm both vertically and horizontally.

Different examples of thin joint brickwork

Technical

Mortar Strengths

The main supplier of mortar for thin joint brickwork is Ankerplast in Belgium. There are currently three types of Ankerplast mortar: Class A, B and C. The choice of mortar depends upon the water absorption of the brick. Ankerplast mortar has been tested at Oxford Brookes University for compressive strength and it achieves approximately 20N/mm2 at 28 day strength. The maximum particle size in the mortar is approximately 1mm.



Thin joint brickwork has enhanced compressive strength due to the thinner joints. Euro Code 6 provides guidance on bed joints up to 3mm, but compressive strength reduces significantly for thicker joints. Compressive strength is generally not an issue for traditional brick cladding, and compressive strength for standard 10mm wide bed joints can be used.

Flexural Strength

Euro Code 6 has tables which include flexure strength. In Europe the external masonry leaf often acts purely as a rain shield, with the flexural strength being provided by a thicker inner leaf. Hence there is little design guidance on flexural strength.

Flexural strength is dependent upon the water absorption of the brick and a detailed testing programme needs to be undertaken to determine flexural strengths, to provide adequate design data. Some initial wallette testing to determine flexural strength has been carried out at both Oxford Brookes and Kingston University. The results compare favourably with mortar designation Class (i)(ii)(iii).

02

Wall Ties

It is important that the correct type of stainless steel wall tie is specified for use with thin joint masonry. Normal ties for use with standard brickwork are not appropriate.

This joint brickwork may not coordinate with the inner leaf, and as a result thin bed wall ties are generally fan-fixed or fixed within slotted channels. In Europe thin joint wall ties have been developed which are physically bent between the two leaves. However, tests carried out at Oxford Brookes University show that these do not comply with DD 140.

This joint brickwork ties have to fit within a bed joint width of typically 3-4mm and the wall tie should have neither a thickness nor diameter greater than half the declared value of the joint thickness, and have a profile height not greater than 0.75 times the declared value of the joint thickness.

Timber Frame

This joint wall ties are readily available for use with timber frame construction.

Lintels

Traditional lintels can be used for thin joint brickwork. In Belgium work has been undertaken to omit lintels altogether and rely on the thin joint brickwork and bed joint reinforcement. The omission of lintels does, however, need to be justified by testing. Discussions have been held with BRC concerning the use of thin joint reinforcement, and it is investigating a stainless steel bed joint reinforcement for thin joint brickwork.

Movement Joints

In Europe the recommendation for movement joints is typically 20 the frequency of traditional brickwork. However, joint centres have recently been increased to the frequency of traditional masonry. Traditional movement joints have 10-12m spacing.

Brick & Block Construction

Due to the difficult cracking height that may occur between brick and block, care thought needs to be given to the suitability of the wall ties to be used.

Ties suitable for use with thin joint brick and block construction are available from Ancon Building Products and also from Powerplase Ltd, and also from other manufacturers.

Ties similar to the 'Fastrack' short channel strip were found to be adaptable for use, regardless of the size of the block used to form the inner leaf.

03

Prefabrication

One of the great benefits of the thin joint masonry is its suitability for prefabrication: - either in a factory environment or on site. Panels of variable size and shape may be produced by bricklayers in either situation. The main benefits include:

- High quality / consistency in workmanship
- A panel production process which is independent of weather conditions
- Reduced wastage
- Tighter control over panel manufacture
- Faster on-site construction
- Reduction in on-site trades
- Reduction in on-site supervision time
- High degree of versatility with respect to other structural systems

Prefabricated brickwork panels made with thin bed mortar generally attain higher strengths and faster setting times than traditional cementsand mortars.

Prefabricated thin joint brickwork

Key considerations in terms of the prefabrication design process include choice of:

- Panels of a manageable shape and size. As with all masonry, the key to efficient design lies not only in the structural adequacy of the components, but also in the detailing. Where possible, elements should be a size which allows for manageable transportation. This may be enhanced by the use of appropriate edge detailing to control working dimensions.
- Appropriate fixing and connection systems with respect to the superstructure. Fixing details are critical when considering the overall stability of the building. The interaction between panels and the beams and columns by which they may transfer load back to the superstructure requires careful consideration.

From a practical point of view, prefabricated panels should not exceed one storey in height. This not only improves on-site handling techniques, but also keeps temporary works to a minimum.

The versatility of the thin bed adhesive system is such that for a given project it may be feasible to utilise all three methods of construction, i.e.

- Factory built component - for small repetitious elements
- Prefabricated panels made in-situ - where larger panels may make heavy, long distance transportation inappropriate
- In-situ construction - where complex shapes and details would be better constructed as work proceeds..

Initial prefabrication is based upon manual bricklaying processes. However, where panel quantities become high, it is envisaged that automatic bricklaying techniques (already in use for glued blockwork in Europe) will be developed here in the UK.

The simplicity with which prefabrication or in-situ processes may be interchanged to suit the design requirements make thin joint brickwork a serious option for the façade solution for both cladding and structural components.

Prefabricated thin joint brickwork

Further information is available at www.ThinJointBrickwork.co.uk but for more detailed information on the project a report can be purchased from the School of Architecture at Oxford Brookes University.

The above information has been prepared to the best of knowledge of the authors; they assume no responsibility for any errors in its use and any loss or damage arising from its use. The panel would like to thank Kingston University for their contribution to the project.

05

'Fastrack' channel and tie

The 'Fastrack' Channel is built into the inner leaf of blockwork, ready to take an Ancon SD28 or similar tie for the outer leaf. This method of construction avoids the dangers of projecting ties. 'Fastrack' ties are available in different lengths to suit various cavity widths. Ancon 'Fastrack' Channels and Ties sustain loads which exceed the requirements for a Type 2 tie to DD140. .

Construction

Laying thin joint brickwork involves a new approach on site, and operatives need to be trained in its use. Several operatives at now trained in the UK, and training can be provided by brick manufacturers.

Mortar Machine

Thin joint brickwork is mixed and laid using a proprietary machine. Machines are available for hire in the UK. The machine mixes the mortar and dispenses it via a two part gun nozzle.

The machines are imported from Europe and often run on 240 volts, and 110 volts transformers are required on UK sites. The pump is generally placed on the scaffold, which can mean slightly wider scaffolds in order to maintain access. The length of the pipe from the gun to the machine is typically 8m, giving a working span of approximately 15m. The machine needs to be thoroughly cleaned at the end of each day, preferably with a pressure washer.

Twin beads of glue being dispensed by gun

Glue to perpends

Brickwork Laying

The bed joints can be continuously mortared with the gun and the perpends are mortared by slipping the bricks on their ends in rows and continuously mortaring prior to placing. Once the mortar is mixed it quickly starts to cure, and continuous operation is required is order to prevent the gun from blocking. It is reconmended that operatives take phased breaks to ensure a continuous operation; however, immersing the gun in a bucket of water can help to prevent short-term hardening.

Care needs to be taken to avoid mortar falling onto exposed masonry as the removal of morts can prove problematical. The laying of thin joint brickwork is to a higher tolerance than traditional masonry, and operatives need to gain experience in order to achieve similar laying rates.

Thin joint brickwork should not be laid in cold weather, and cold weather guidance for traditional masonry should be adopted. Thin joint brickwork also needs to be protected once laid, as with traditional masonry.

04

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Prefabricated cavity walls – the potential for vacuum insulated panels

Case study – University of West of England, Dept of Planning and Architecture

- University of West of England
- First thin bed scheme in the UK
- All construction in-situ
- Thirty thousand 290x90 clay bricks
- 5mm black joint in beds and perpends

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Prefabricated cavity walls – the potential for vacuum insulated panels

Developments in prefabricated masonry

- **Some prefabricated work has been undertaken in Europe**
- **Design processes not covered by UK Codes**
- **Work relates to thin jointed masonry and composite concrete panels**

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Prefabricated cavity walls – the potential for vacuum insulated panels

BRE Offsite 2005 – concept for Hanson House

- **Objective**

  To construct a “standard” house type which incorporates various Hanson products including standard components and new / innovative building systems

- **3 bed detached house**
- **Basement**
- **Prefabricated aggregate block cavity walls**
- **Prefabricated garage module**
- **Clay brick slip composite cladding finish**

Prefabricated cavity walls – the potential for vacuum insulated panels

BRE Offsite 2005 – development of prefabricated masonry

- **Ground floor walls comprised inner and outer leaf construction in aggregate blocks with a cavity insulation**

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Prefabricated cavity walls – the potential for vacuum insulated panels

BRE Offsite 2005 – concept for Hanson House

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Prefabricated cavity walls – the potential for vacuum insulated panels

The Hanson EcoHouse™, BRE Offsite 2007 - Key Drivers

- **Buildability**
  - Practicality
  - Aesthetics
  - Air tightness
  - Security
  - Longevity
  - Acoustics
- **Sustainability**
  - Eco Homes Rating
  - Thermal Mass
  - Recycling
  - Efficient Water Use
  - Waste Reduction
- **Futability**
  - Energy Saving
  - Control & Monitoring
  - Flexibility
  - Re - use

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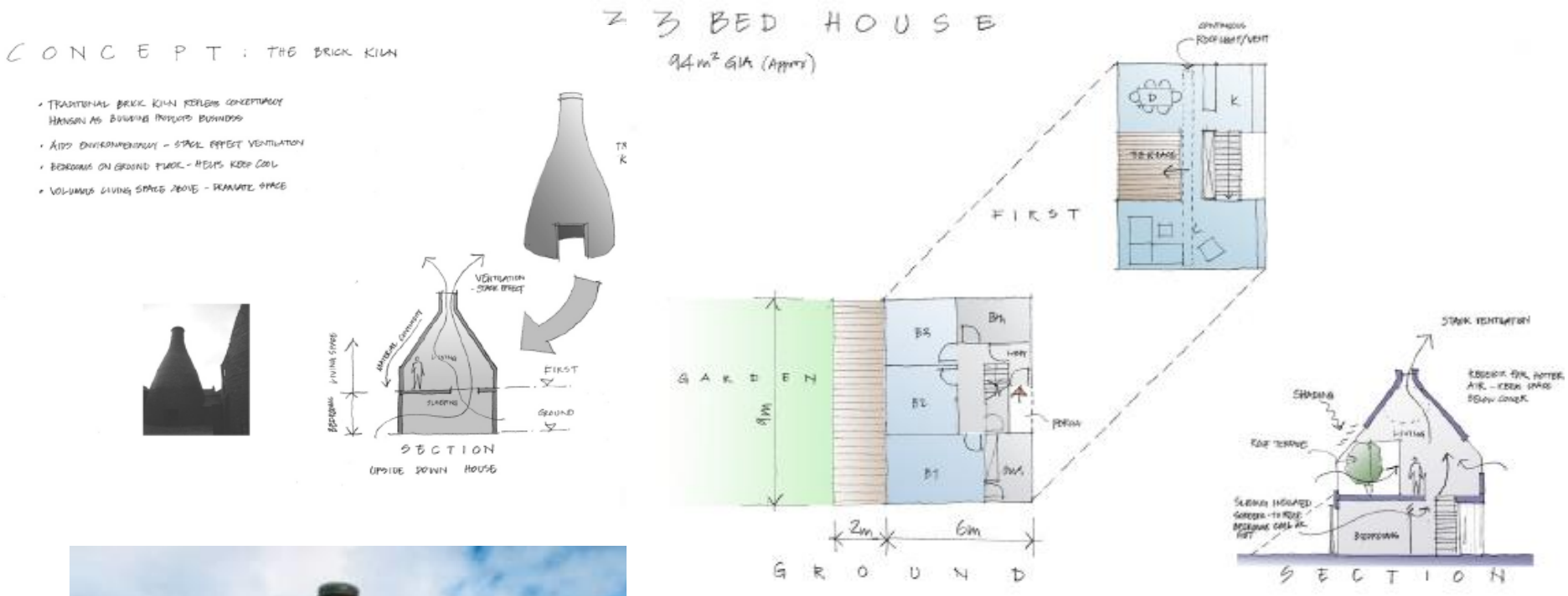
Prefabricated cavity walls – the potential for vacuum insulated panels

BRE Offsite 2007 – concept for Hanson EcoHouse™



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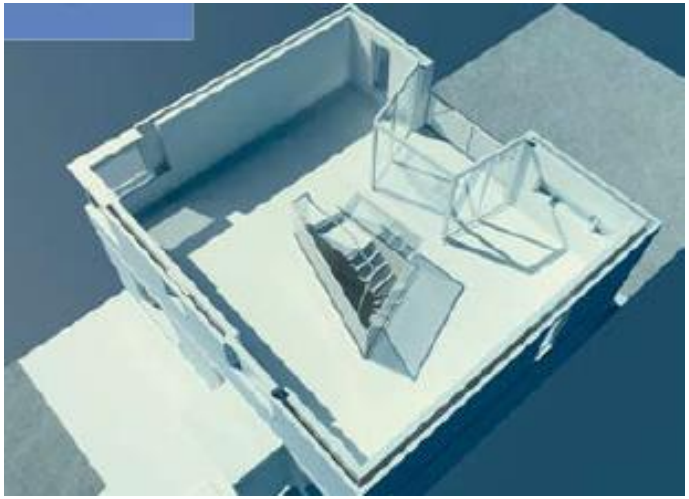
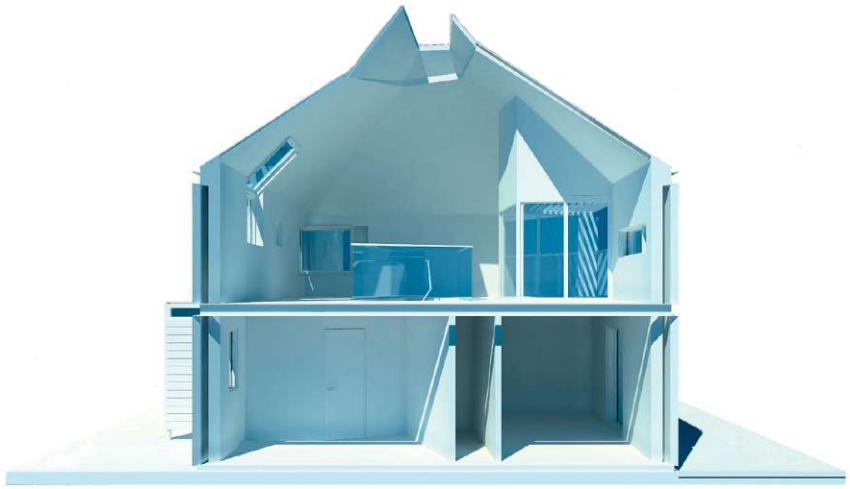
Prefabricated cavity walls – the potential for vacuum insulated panels

BRE Offsite 2007 – concept for Hanson EcoHouse™





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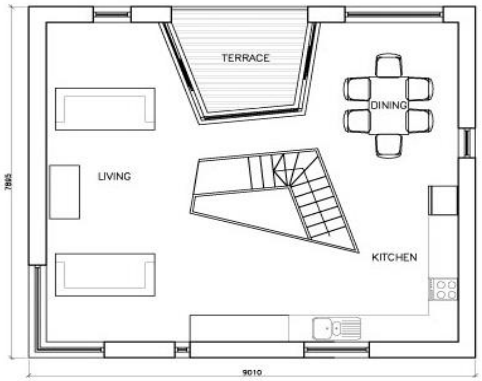
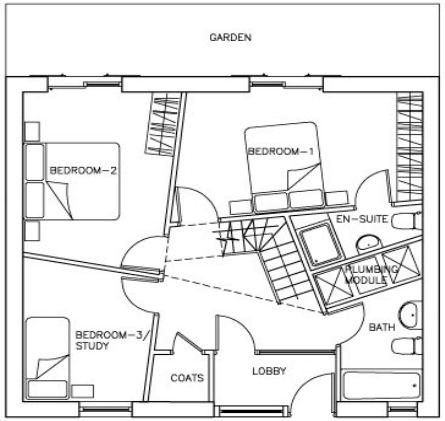
Prefabricated cavity walls – the potential for vacuum insulated panels

BRE Offsite 2007 – concept for Hanson EcoHouse™





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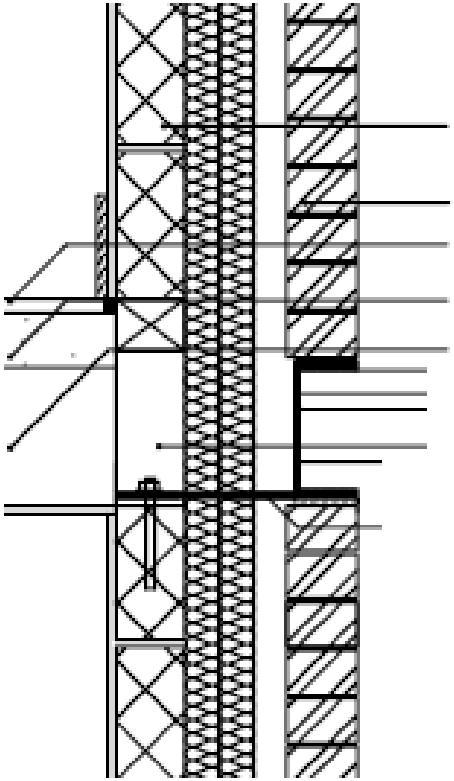
Prefabricated cavity walls – the potential for vacuum insulated panels

The Hanson EcoHouse™ - The QuickBuild™ prefabricated walling system



100mm thick high density concrete block

102mm face brickwork

20mm floor finish zone

80mm screed and underfloor heating pipes

200mm thick hollowcore floor slab

Overall width including plaster finish = 365mm

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Prefabricated cavity walls – the potential for vacuum insulated panels

The Hanson EcoHouse™ - The QuickBuild™ prefabricated walling system

Benefits of prefabrication :-

- Complete wall panel including insulation manufactured in factory
- Versatility in selection of wall materials including insulation
- U value of 0.18 achieved
- 4 no wall panels transported in each load
- On site erection – 4 man team
- Very high level of dimensional accuracy

Up to 9m long x 2.5m high

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Prefabricated cavity walls – the potential for vacuum insulated panels

The Hanson EcoHouse™ - The QuickBuild™ prefabricated walling system

Code for sustainable homes – level 4

Benefits of prefabrication :-

- Speed of build – 4 days for superstructure
- Tried and tested products – standard masonry materials and flooring systems
- Safer on-site erection
- Reduced site waste
- Easily extended
- Enhanced air tightness
- Reduced need for scaffolding
- Accommodates precast concrete floors (larger spans with greater flexibility)
- Reduced need for lintels
- Pre installed wiring loops
- Pre plastered finish

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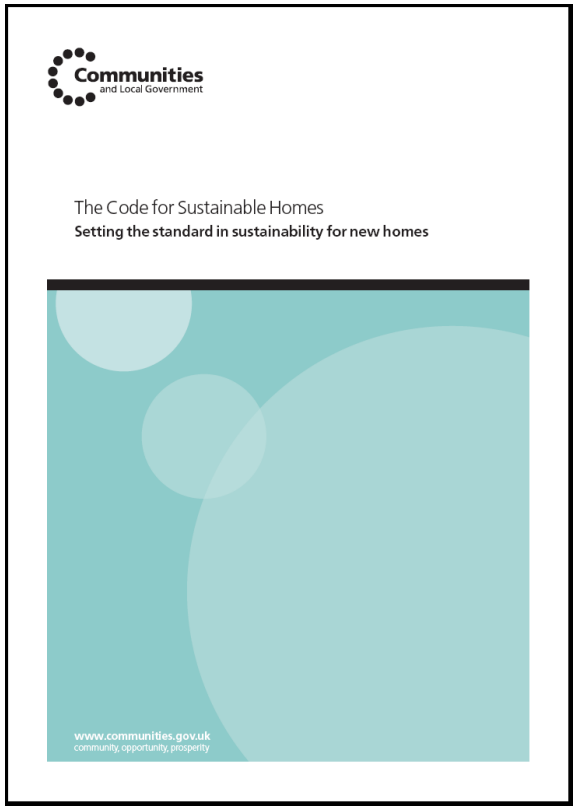
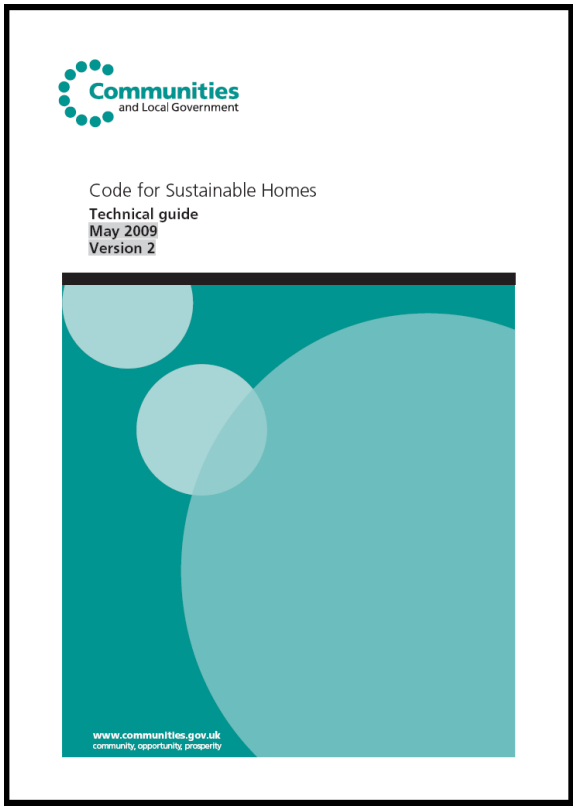
Code for Sustainable Homes (CSH)

- Introduction to the Code for Sustainable Homes





The CSH is an environmental assessment method for rating and certifying the performance of new homes

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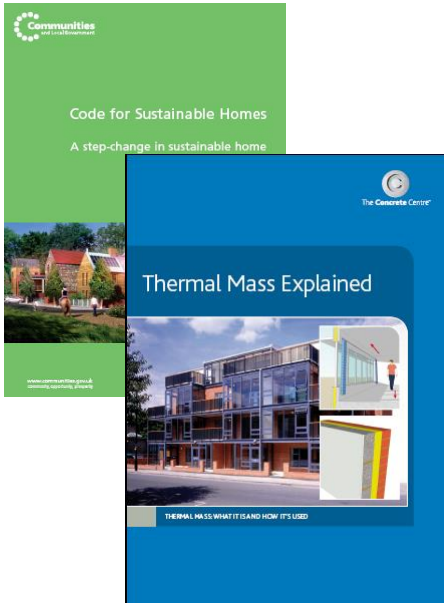
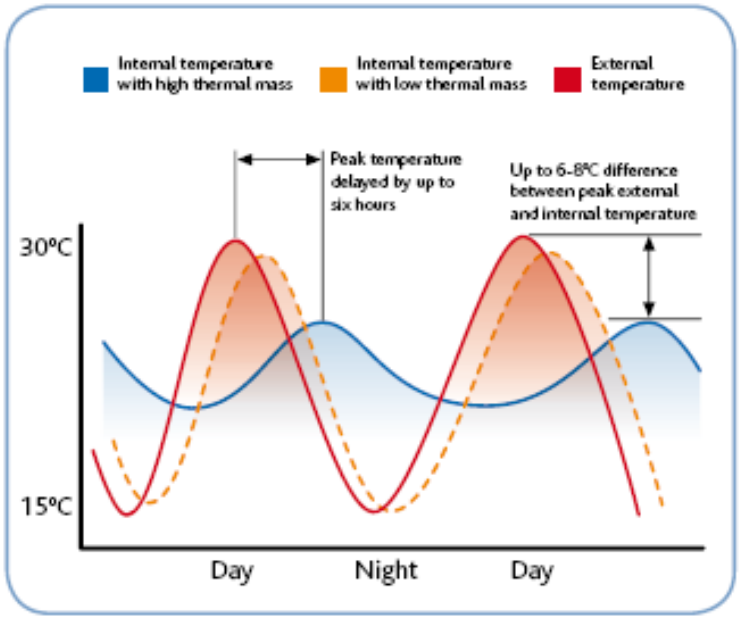
Code for Sustainable Homes (CSH)

The Hanson EcoHouse™ - Thermal mass





For material to have useful level of thermal mass, 3 properties are required:-

- **High specific heat –** to maximise heat that can be stored
- **High density –** to maximise overall weight of material
- **Moderate thermal conductivity –** so that heat conduction is in synchronisation with diurnal heat flow in and out of the building

Heavyweight materials such as concrete and masonry have these properties

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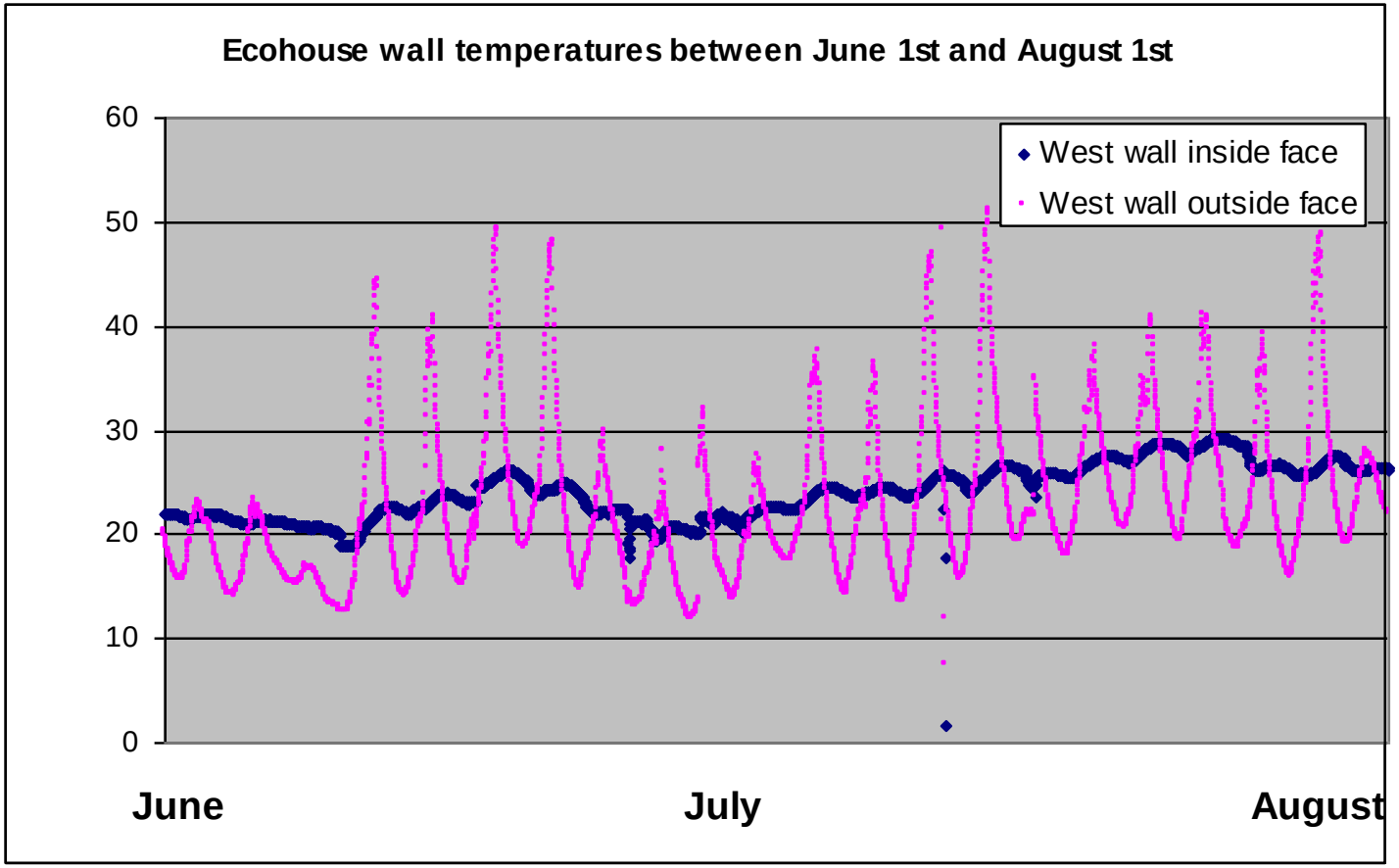
Code for Sustainable Homes (CSH)

The Hanson EcoHouse™ - Thermal mass



No matter how hot it gets outside during the day or how much cooler it gets during the night inside the house it's always just the right temperature!

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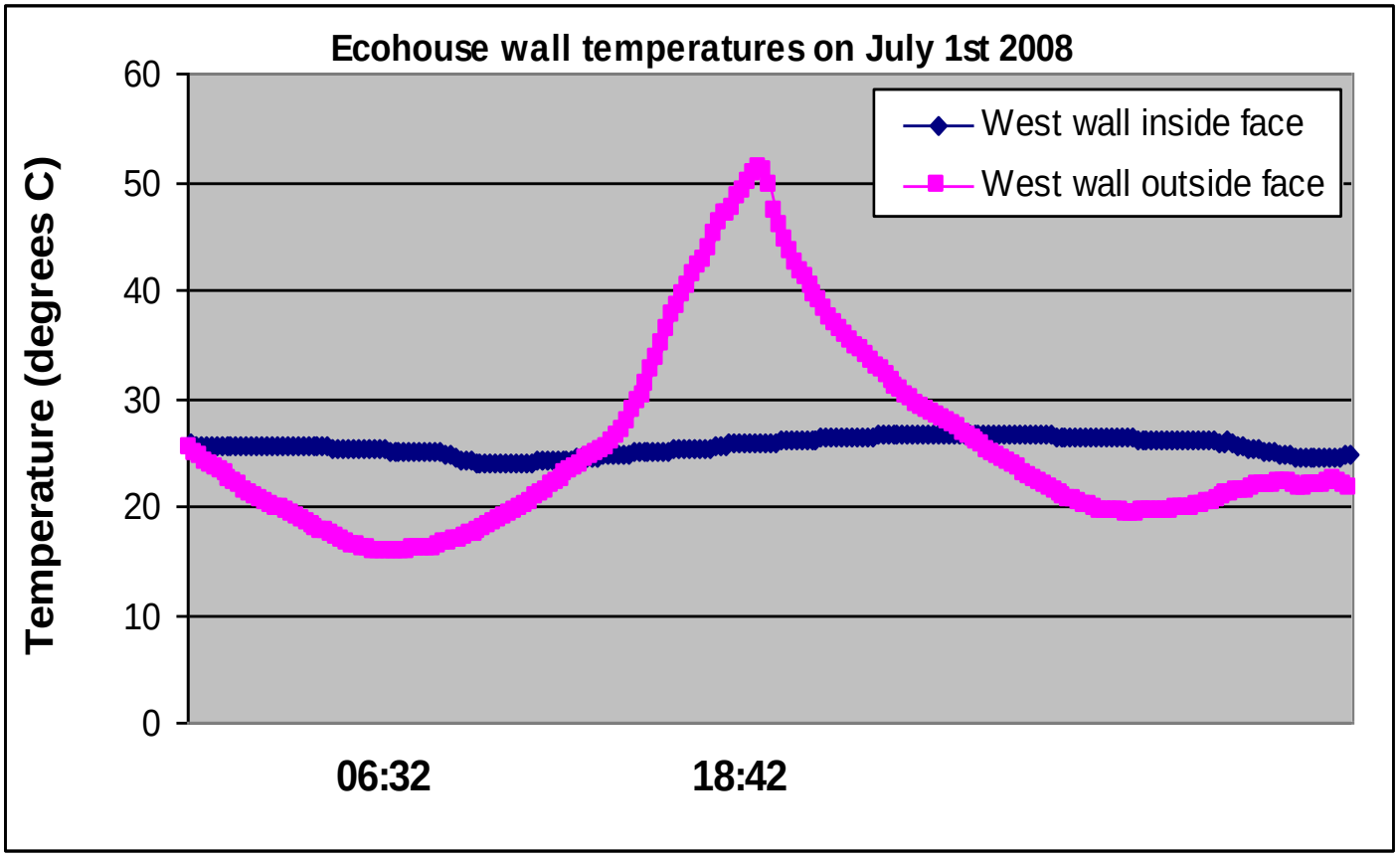
Code for Sustainable Homes (CSH)

The Hanson EcoHouse™ - Thermal mass



Temperature Stability is key to a comfortable internal climate and the Ecohouse wall construction demonstrates brick and block's superior benefits for the occupier

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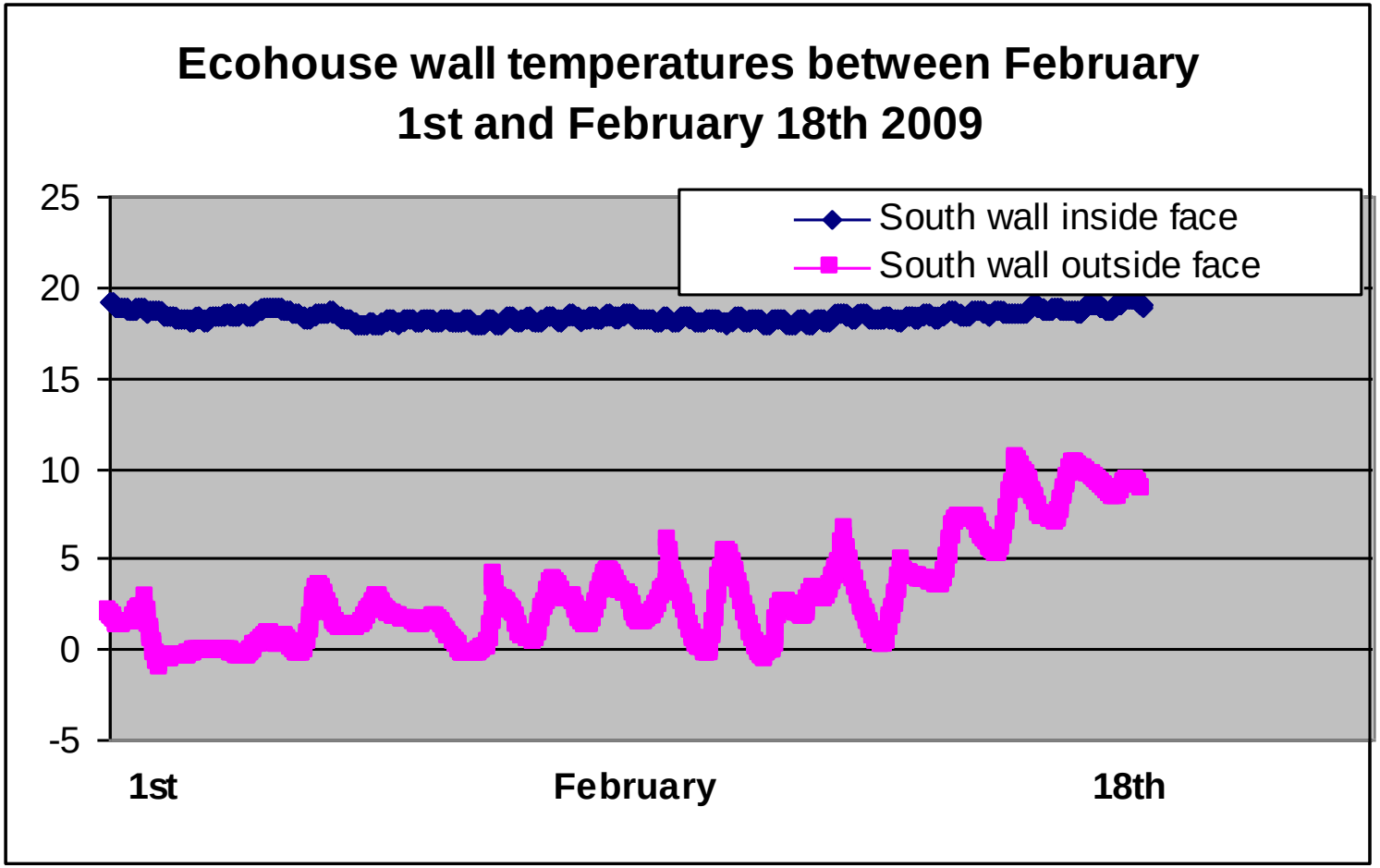
Code for Sustainable Homes (CSH)

The Hanson EcoHouse™ - Thermal mass



It's constantly warm inside whatever the winter throws up!

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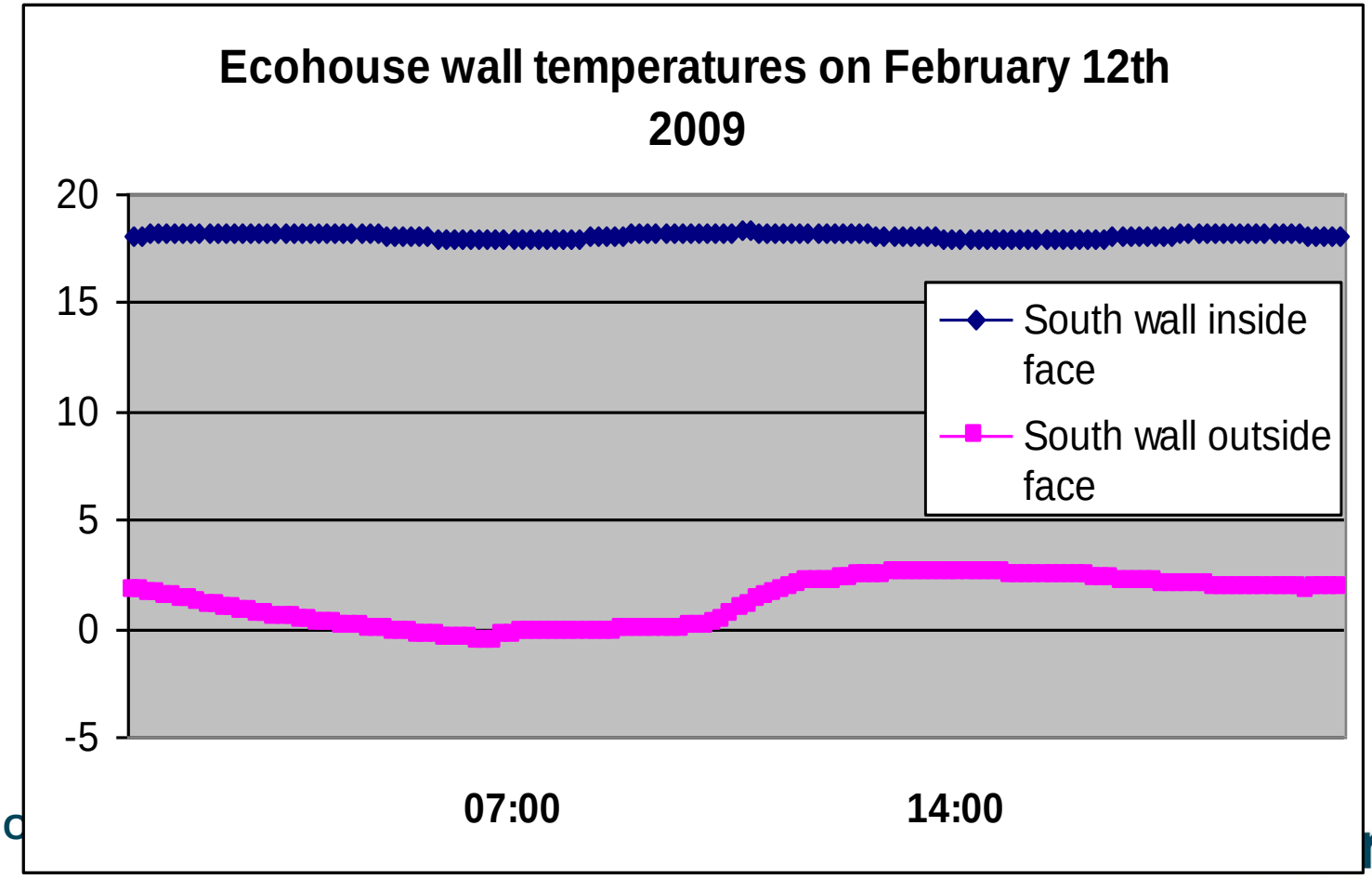
Code for Sustainable Homes (CSH)

The Hanson EcoHouse™ - Thermal mass



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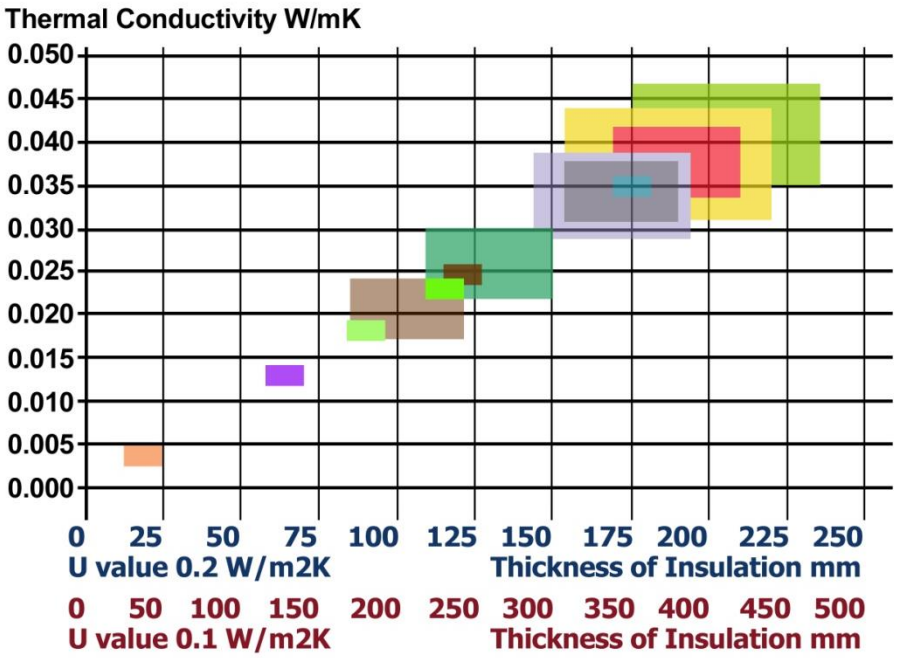
Prefabricated cavity walls – the potential for vacuum insulated panels

Performance of insulation types

Insulation Thicknesses for U values W/m2K

Key to	Insulation Product Range	U value Range
	Cellulose Fibre	0.2 W/m2K
	Glass Wool Fibre	0.1 W/m2K
	Rock Wool Fibre	
	Expanded Polystyrene	
	Extruded Polystyrene Foam	
	Polyurethane Foam with CO2	
	Polyurethane Foam with Pentane	
	Phenolic Foam	
	Polyisocyanurate Foam	
	Phenolic Foam with Foil Face	
	Polyisocyanurate Foam with Foil Face	
	Aerogel Blanket	
	Vacuum Insulation	



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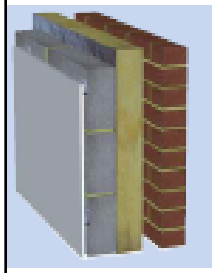
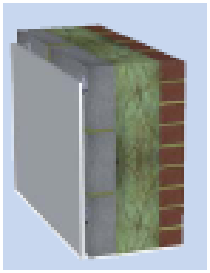
Prefabricated cavity walls – the potential for vacuum insulated panels

Increasing cavity wall thickness – the influence of U values



Brick / 50mm air gap / P U board (λ = 0.023) / Inner leaf - 100mm Thermalite Turbo block (aircrete) / dry lining						
U-value (W/m^2K)	0.15	0.18	0.20	0.22	0.25	0.27
Wall thickness	375mm	332mm	320mm	310mm	300mm	292mm
Insulation thickness	125mm	82mm	70mm	60mm	50mm	42mm



Brick / mineral wool (λ = 0.032) / Inner leaf - 100mm Fenlite block / dry lining						
U-value (W/m^2K)	0.15	0.18	0.20	0.22	0.25	0.27
Wall thickness	400mm	375mm	340mm	325mm	315mm	300mm
Insulation thickness	200mm	175mm	140mm	125mm	115mm	100mm

As the U value decreases,

insulation material thickness increases

Insulation contributes between 80% - 90% to the wall U value

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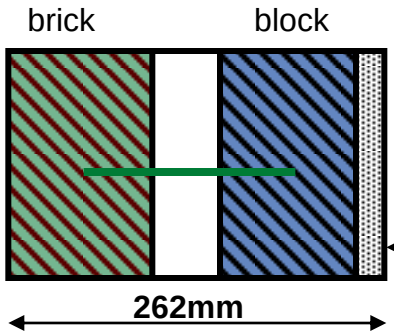
Prefabricated cavity walls – the potential for vacuum insulated panels

Increasing cavity wall thickness – the influence of U values

Pre 1970

U value = 1.0

wall tie =150mm

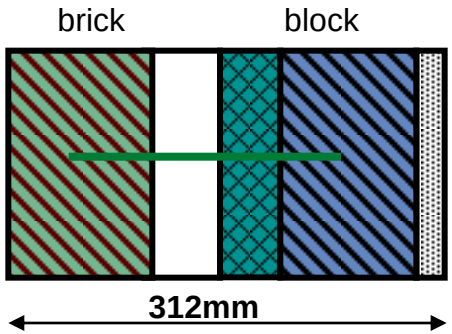


Cavity wall overall width increase =113mm (43%)

1985

U value = 0.6

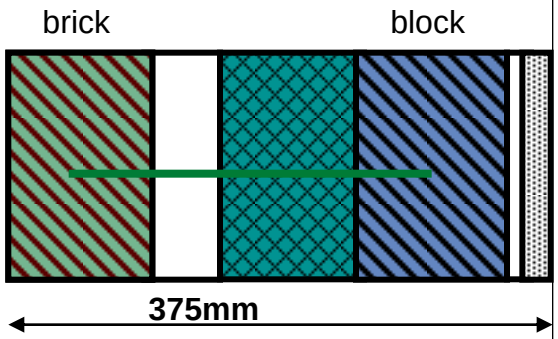
wall tie =200mm



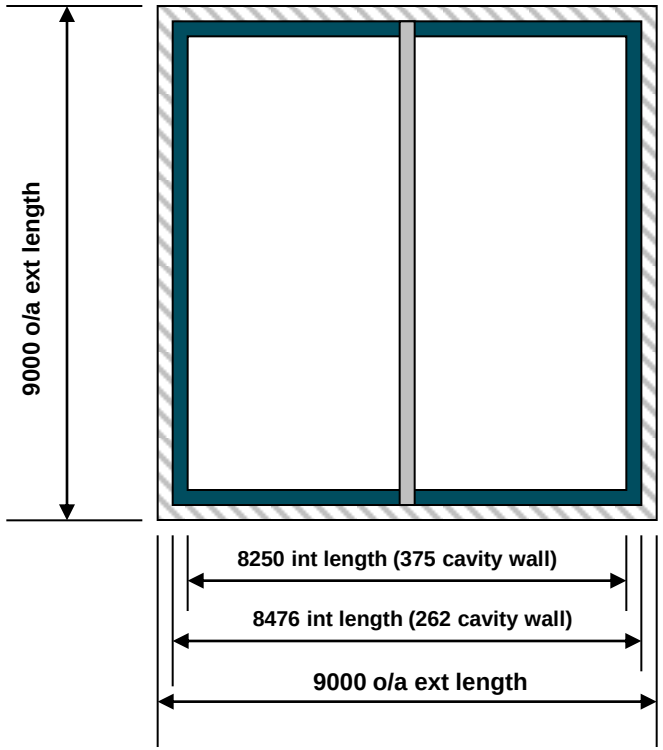
2007 BRE Hanson House

U value = 0.18

wall tie =250mm



Typical floor space for a pair of semi detached dwellings



262mm cavity wall….. Int floor area = 71.84m²

375mm cavity wall……Int floor area = 68.06m²

Loss of internal floor space ……. = 3.78m²

Hanson
HEIDELBERGCEMENT Group

Prefabricated cavity walls – the potential for vacuum insulated panels

The Challenge – and opportunity :-

- Design vacuum panel to fit in a thin cavity, say 50mm
- Provide a panel with sufficient resilience / robustness that it cannot be punctured
- Ensure panel sizes co-ordinate with other ancillary products ie wall tie spacing
- Develop connection details between adjacent panels
- Aim for a long warranty period – as is given with other masonry products within a cavity wall
- Vacuum panel maintenance – how often & how costly?
- Competitive costing – clear and simple comparison required of initial costs, maintenance and energy saving benefits.

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