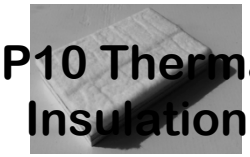
JP10 Thermal Insulation



Thermal Insulation Master class

BrianSpecMan 4th July 2023

This Presentation on GBE:

- Find this file on GBE websites at:
  - https://GreenBuildingEcyclopaedia.uk/?p=40839
- Go there for:
  - the latest update
  - versions presented to different audiences
  - the whole presentation, all of the hidden slides
  - other file formats:
    - Handout, Show, PDF, (PPTX in shop)
  - Links to related: GBE & GBC CPD & other content
    - CPD, Lectures, Checklists, Jargon Busters, Issue papers, Q&A, Links, etc.

Thermal Insulation Functions

In use Carbon and Energy Reduction

Thermal comfort Moisture management

General Competency Issues

- Comply with Code of Practice or Workmanship British Standards or WOBS
- Products manufactured to BS standards and BSI Kitemarked ideally (or ENs and Kitemark)
- BBA Certified systems if no Kitemark
- Manufacturer recommendations should never be ignored
- BBA certificates should be checked for limitations too, stay within them
- Check currency of test evidence
  - (ideally post Grenfell)

Regulated Issues

- Stuff we should understand
- k values of materials and products
- r values of materials of known thickness
- Surface resistivity at faces and in voids
- U values of whole elements
- R values if European/International
- Do you do your own calculations?
  - If not, do you check them for competency?
  - I have found manufacturers fudging values
- GBC V2 Includes U value calculators for all elements
- GRC V1 will too when issued

Unregulated Issues

- Stuff green manufacturers understand
  - but we tend not to know nor exploit
  - More research is done but not readily accessible
- Hydrophobic insulation
  - Vapour closed construction
- Hygroscopic insulation
  - Vapour open construction
  - Breathing walls & roofs

Unregulated Issues (BRAD O)

- BRAD O does not understand opaque building envelop permits solar radient heat inwards
- Solar Radiation Heat gain
- K value
- Density
- Specific Heat Capacity
  - Thermal Mass
    - storing heat in its thermal mass, if it has any
  - Decrement delay or Thermal lag
    - heat passage over time through insulation to interior

Meeting Targets: means Avoiding Substitutions

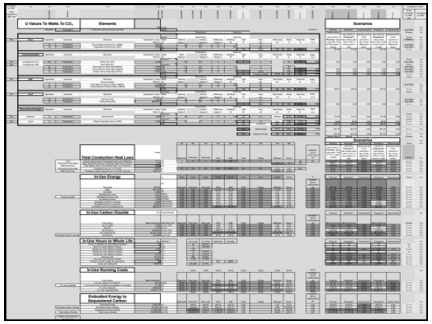
- Specify the reasons you chose it
- Make those reasons the criteria for substitution equivalency
- Don't say 'or similar' say 'or equivalent' and check equivalency
  - In annotation (don't undermine the specification)
  - Nor in the specification it encourages substitution
- Police your specification
  - Choosing Contractors, Suppliers, Installers
  - At price gathering and at tender stage
  - On site: Delivery tickets, packaging, products
  - As installed
  - At stage payments "Here be dragons"
  - (signing off stage payments approves surreptitious substitution)

Violet v Green Contractors

- Violet contractors know what they know
- Have supply chains in order
- Buy the day they need it from merchants
- They don't like change: Business as usual
- Get them to do the TGR's Futureproof online training courses for sustainable retrofit subcontractors
- https://www.futureproof.uk.net/
- futureproof@cse.org.uk
- So they know why and how to change and want to change
- And not bother to bring spurious substitutions
- And get satisfaction they are part of the solution

Cost savings now, cost later

- Working with your client and the contractor
- Understand that initial cost savings will probably increase :
  - in-use cost
  - in use Energy and Carbon
  - Embodied Energy and Carbon
- Use Green Building Calculator to see all of the costs and impacts before you decide
- Making changes in GBC will instantaneously provide you with the consequences of any change of specification or targets



Pay back & carbon back periods

- Renewable energy systems are an add on cost
- Push-back comes in the form of 'what is the pay-back period' usually associated with energy costs
- More importantly are carbon-back periods
- If your client is switched on to carbon saving
- Provide them with that information too
- Green Building Calculator aims to provide this data in future
  - Focus on Insulation payback periods
  - Focus on high specification window payback periods
  - Focus on the cost of adding and running air conditioning
  - Focus on PV to EV on the drive not having to pay for fuel again
- Challenge payback period of £1000 tap or door handle

Adding real value

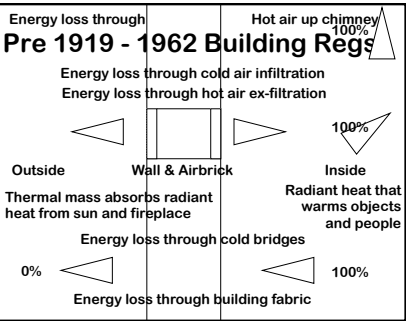
- Estate agent's perceived 'adding value': if your selling it
  - Location Location Location in relation to schools
  - Increasing floor area,
  - Posh kitchens and posh bathrooms
  - Kerb appeal
  - Neutral colour, clutter-free interiors
- Home owners perceived adding value:
  - Being able to boast about how cheaply you extended/altered your house is not adding value
  - With increasing fuel and living costs, long term low running costs need to be perceived as adding value?
  - A to G ratings enable engagement
  - Boasting your 6 Bed house costs £50/year to heat and cool not £2000/year at the school gate has to be seen as adding value?

History Lesson

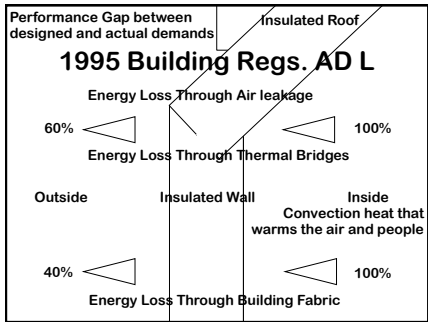
Just my opinion

GBC will confirm or not

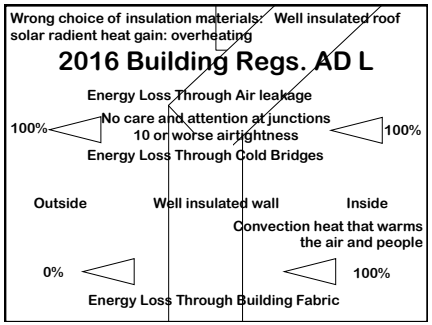
Pre 1919 - 1962 Building Regs



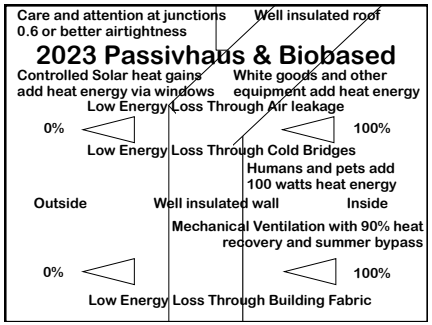
1995 Building Regs. AD L



2016 Building Regs. AD L



2023 Passivhaus & Biobased



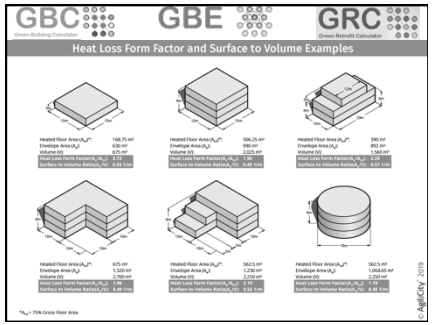
CO_2 and Energy demand targets

- Set out to meet or exceed:
  - Kyoto, Paris, EU or UK CO_2 targets,
  - or ACAN, LETI, RIBA campaigns (but silos still apply)
- Do not limit projects to complying with Building Regulations Approved Documents L1A, L1B, L2A, L2B they are not yet aiming to meet any targets
  - Weak Regulations since 1965 could be blamed for Climate Change
  - but coal, oil and gas are the real culprits
- EcoHomes & Code for Sustainable Homes
  - Challenged Building Regulations
  - CfSH strived for Zero Carbon buildings by 2016,
  - Industry responded and invested for one up man ship
    - Lots of bad application and lessons learned
  - but were optional,
  - challenged by profit hungry developers and now no longer available
  - Some T&CP still ask for them

Reduce Your Targets

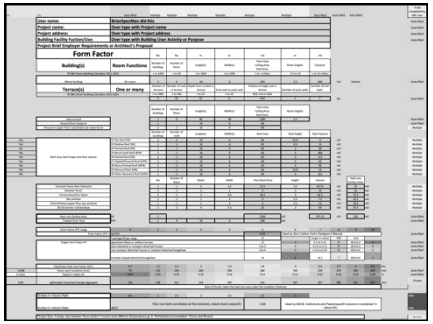
- Reduce heating, cooling, ventilation and air-conditioning demands towards zero
- Insulation costs less than heating and cooling plant so insulate
- Windows: U value of 1.0 W/m2.K or better targets 0.75 W/m2.K
- Walls: U value of 0.1 W/m2.K or better
- Airtightness: Building Regulations Approved Document L less than 1, (0.6 PH) not 10 required by BRADL
- An existing unusable library survey
  - Howling wind through windows
  - Papers fluttering across table
  - Airtightness tested at 8
  - Then reduced to 2 in an hour with smoke wands and tapes

Form Factor



Form Factor dictates heat loss

- Ratio between external envelop and floor areas
- Spherical is optimum but impractical and costly
- Compact square plans, cubical volumes best
- L, C, O, I, H, T, X shaped plans worse
- Bungalows worse than Apartments
- Villas worse than Terraces
- Bay, Oriel, Dormer, Porch, Extensions, Conservatory, recessed covered walkways: all worse Form Factor
- Towers with multiple occupancy: okay
- Towers with single occupancy: not so good
- Form Factor included in GBC V2



Form Factor suggests Targets

- With a Form Factor Calculator
- You can determine U value Targets
- That are more important than BRADL
- A large form factor will always use more energy to heat or cool
- So U value should be correspondingly more onerous
- or it will be expensive to occupy

Changes of Direction/Plain

- Junctions between elements
- Corners between walls
- Angles between planes
- Are all costly:
  - Are all more labour intensive
  - All generate offcut waste
    - (in factory, on site or both)
  - Are often thermal bridges that loose heat
  - Are often air leaky where heat is also lost

Orientation

Orientation of what?

- Building orientation: can influence building performance
  - Plan shape and orientation
    - Area of external opaque surfaces facing sun,
    - Pitched roofs in particular (potential overheating),
  - Volumetric shape (form factor)
- Windows, Glazing: solar heat gain
  - South: needs shading in summer, solar access in winter
  - East & West: Morning and evening heat gains at low angles
  - North: heat free daylight, but heat loss too
- Roofs: facing the sun at different times of day
  - For Renewable energy systems
  - Use PV on more roof orientations to match energy supply to energy demand over longer period of day,
  - Do not maximise battery capacity for mid day only gains
  - Not just south facing and not just at 30 degree pitch
  - Vertical in winter (Bill Dunster at FutureBuild 2023)
  - Potential to overheat attic and top floors

- Form Factor: So high
- South facing?: No shading
- 6 bathrooms: Who's cleaning them?
- £100,000: to pay for:
  - summer air conditioning
  - winter heating bills
  - House maid

Orientation

- Solar heat gains can be beneficial in winter if exploited well
- Solar heat gains can be detrimental in summer due to overheating
- Opaque building fabric needs thermal mass OR
- Insulation material choice will exacerbate or solve overheating

Internal Heat Transfer

Keep heat in its place of arrival

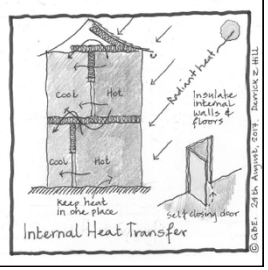
Maintain safe refuge on the cooler side

Insulate internal floors and partitions

Self closing doors

Promoted by BedZED

Rotate around rooms of the house to stay cool



Thermal Bridges Geometry dictates & Material choices

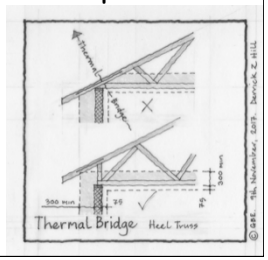
Thermal bridges will ruin any choice of insulation material performance

Thermal bridges will let conducted heat out, conducted coolth in and solar radiant heat in

Eaves details are most vulnerable

300 mm of insulation reduced to 50 mm is asking for trouble

Risking interstitial condensation, surface condensation, mould, structural failure, asthma, toxic mould and death



Thermal Breaks

High Density Expanded Polystyrene

- Strong enough for nails and screws
- For securing windows, doors, etc.
- Embedded in walls
- Moisture tolerant
- Thermal insulation but poorer k value

Thermal Bypass & Wind Washing

- Wind washing at eaves
- Essential eaves ventilation to prevent condensation
- Cold air from eaves ventilation can blow the warmth out of the ceiling insulation
- Install a wind baffle to maintain ventilation route past the insulation edge

Thickness

Carbon and Energy Reduction

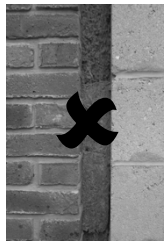
Insulation thicknesses required to achieve a U-value of 0.2W/m²k

235mm	Cellulose fibre
220mm	Glass wool fibre
210mm	Rock wool fibre
190mm	Extruded polystyrene foam
185mm	Polyurethane foam with CO_2
180mm	Expanded polystyrene
150mm	Polyurethane foam with pentane
135mm	Phenolic foam
130mm	Polyisocyanurate foam
120mm	Phenolic foam with foil face
95mm	Polyisocyanurate foam with foil face
75mm	Aerogel blanket
25mm	Vacuum insulation

50 mm. cavity is history

300 – 600 mm. is optimum

Ties and tie spacing may change



BedZED Beddington Sutton Architect: Bill Dunster

Zero Fossil Fuel Energy Development

High thermal mass cavity walls, roofs and floors

Low U values
300 mm.
Rock Mineral Fibre
Long 2 part cavity ties

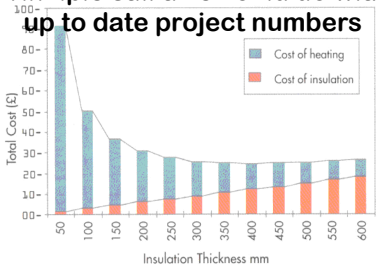
BedZED Beddington Sutton Architect: Bill Dunster

Long ties and deep reveals For 300 mm. insulation

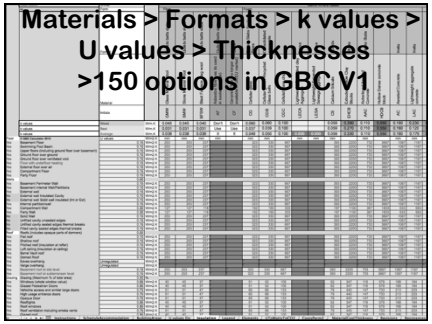
Insulation, Insulation, Insulation

- Spend money on insulation, its cheap
- Save money on heating and cooling plant, it's expensive, reduce plant room sizes
- Save money on heating and cooling bills
- it will get more expensive over time
- Peak oil has been passed
- Prices have been rising
- Government will not intervene

Principle still true could do with up to date project numbers



Materials > Formats > k values > U values > Thicknesses >150 options in GBC V1



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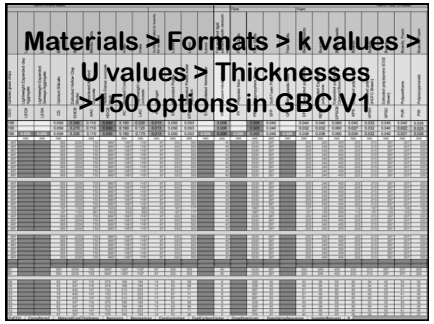


Thick walls, roofs and floors

We have a preoccupation with thin walls 300 mm. or less
Which drives the demand for energy intensive man-made petrochemical fossil derived CFC HCFC HFC HFA foamed plastic
O_3 Ozone Depletion
Greenhouse Gas Potential
300-400 mm. optimum insulation thickness (details)
Avoid problems

Construction Resources Showrooms Southwark London

Construction Resources

Showroom Tour 1:1 Section models

Thermal & Acoustic Insulation
Different eras and climate zones
Another CPD seminar

GBC https://GreenBuildingCalculator.uk GBE https://GreenBuildingEncyclopaedia.uk GRC https://GreenRetrofitCalculator.uk

Wildlife Action

Inhabitation

- Rats, mice, birds, bats enter buildings for warmth, dryness, gnawing food, breeding and sleeping
- Rodents teeth grow continuously, they gnaw materials to keep them short, anything will be tried including timber structure, cables, insulation and membranes
- Insulation is good bedding material

Wildlife Action

- Extruded and expanded polystyrene and even high-density mineral fibre are very seriously attacked by "wildlife".
- That's another mechanism by which you can lose most of the r-value of your insulation.
- None of them appear suitable for use in ground contact as was being recommended just a decade or two ago in Sweden, USA and elsewhere.

GBC https://GreenBuildingCalculator.uk GBE https://GreenBuildingEncyclopaedia.uk GRC https://GreenRetrofitCalculator.uk

Hygroscopic v Hydrophobic

Moisture and its effect on performance

Hydrophobic Insulation in masonry

- Glass and rock mineral wool thermal and acoustic insulation
- If used in wet construction e.g. masonry cavity wall the moisture content of the wall is expected to be 3% MC
- Rainwater can pour down the inside face of the external leaf
- Hydrophobic materials in these conditions will absorb moisture in the surface
- The water will occupy the air spaces and prevent the insulation from acting as insulation
- Its performance drops off unless it can lose the water
- High resin content can offer some resistance to water uptake
- Fibre orientation or disorientation can discourage capillary attraction into the depth of the insulation
- Allegedly the insulation keeps the moisture close to the exposed surface and little of the insulation`s thickness loses performance

Hydrophobic Insulation in timber frame

- Glass and rock mineral wool thermal and acoustic insulation
- If used in dry construction e.g. timber frame wall the moisture content of the wall is expected to be low
- However compromised vapour barriers (VB) are only a Vapour check (VC) and some moisture will enter the construction
- Hydrophobic materials in these conditions will adsorb moist air and water
- The moisture will occupy the air spaces and prevent the insulation from acting as insulation
- Its performance drops off unless it can loose the moisture
- High resin content and non absorbent materials offer resistance to moisture uptake into the fibre so it remains in the airspaces.
- 1:5 ratio is critical to the moisture passing through driven by warm air
- If the insulation holds the water it can hold the water against timber sections
- Timber sections kept wet will rot

Hygroscopic Insulation

- Any natural plant based material: hemp, straw, flax, coconut husk, cellulose, sheep`s wool, grass, etc.
- Air trapped in material is what makes insulation work
- Water does not work in the same way
- Moisture laden air or interstitial condensation occupies the space that air would
- Stops hydrophobic insulation from insulating
- Hygroscopic insulation absorbs the moisture into the fibre leaving the air spaces to insulate
- Releases the moisture when conditions are right and it leaves the construction and building

Hygroscopic Thermal Insulation

Newspaper
Flax
Hemp
Sheep`s wool
Cellulose

Construction Resources Showroom

GBC https://GreenBuildingCalculator.uk GBE https://GreenBuildingEncyclopaedia.uk GRC https://GreenRetrofitCalculator.uk

Decrement Delay Thermal Lag

Construction Resources

Roof Top Extensions

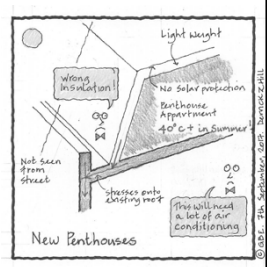
Planners insist on top floor additions set-back

Structure needs lightweight construction

Comes with with wrong insulation

Will overheat

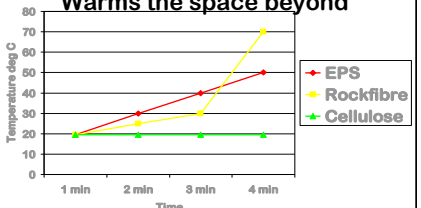
Needs air-con



Construction Resources Showrooms Southwark London

Radiant heat through 50 mm. of thermal insulation types over time

Warms the space beyond

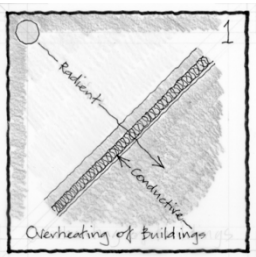


Construction Resources Showrooms Southwark London

GBC https://GreenBuildingCalculator.uk GBE https://GreenBuildingEncyclopaedia.uk GRC https://GreenRetrofitCalculator.uk

Radiant verses Conductive heat flows

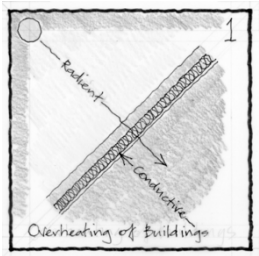
Insulation needs to resist both or overheating occurs



Radiant v Conductive

Thermal Insulation:

Once radiant heat gets in it warms the space and the warmth cannot get out through conductivity insulation



Radiant v Conductive

- UK Government funded insulation programmes
- Refurbishment and retrofit
- Cavity insulation
- Attic insulation
- Cheap materials: glass and stone wool or polystyrene: all conductive insulation
- Will overheat top floors

- The insulation heats up with solar radiant heat
- The insulation delays the passage of solar radiant heat through thickness of insulation
- British Library Euston saw asphalt roofing laid on Foamglas on concrete, heat bounced back and kept asphalt warm, not setting and running down slope, pushed back by installer until cool enough to set
- Uninsulated concrete would soak up the heat and the asphalt set quickly

Building Integrated Renewables

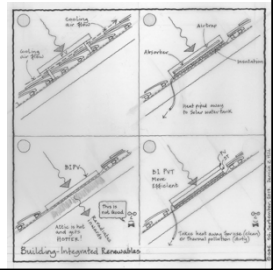
Building Integrated Renewables

Is it really a good idea?

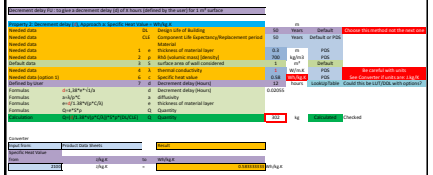
I don't think so

Non-BIR ventilate below and PVs perform better

BIR PV radiate below into a hot attic

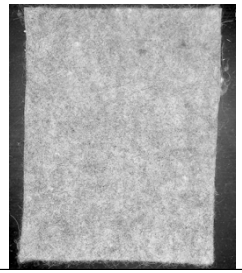


Decrement Delay Equation GBE Green Building Calculator Will be added GBC V3?



Acoustic Insulation

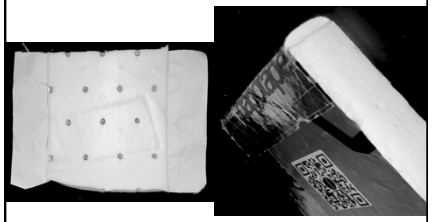
P10 Insulation



Sheep's Wool Acoustic Isolation

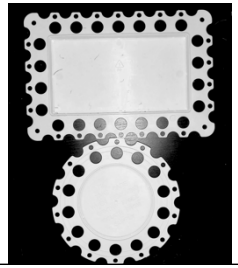
- Used within floor finish build up
- Isolate hard top surfaces from sub-construction
- Footfall should not transfer noises to sub-floor

Airtightness Accessories



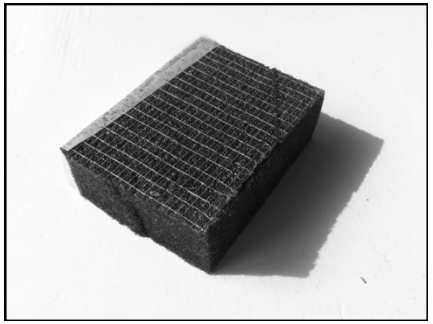
Building Regulations AD L update

- Inaccurate fit rigid insulation (expanded plastic/foil face)
  - Heat loss in winter
  - Heat gain in summer
  - Coolth loss in summer
  - Cold gain in winter
  - Higher than necessary energy demand
    - And carbon from that fuel
  - Interstitial condensation risk
    - Mould risk
    - Rot and Structural failure risk
- The only practical competent solution: GapOTape
  - Self adhesive compressible insulation
  - Bonded to edge of rigid insulation boards
  - Squeeze into framing zone
  - Airtight but forces all moisture through timber framing



Building Regulations AD L Airtightness

- Inaccurate fit/seal electrical boxes and membranes
- Heat loss in winter
  - Heat gain in summer
  - Coolth loss in summer
  - Cold gain in winter
  - Higher than necessary energy demand
    - And carbon from that fuel
  - Interstitial condensation risk
    - Mould risk
    - Rot and Structural failure risk
- A practical competent solution: Bead Master
  - Ready made square, rectangular or circular beading
  - Makes airtight seal with plaster applied
  - Sharp knife & pop out centre panel



Window perimeter insulation

- Self-adhesive Compressed foam strip
- Fix to perimeter of windows
  - Install windows within 3 hours
  - Foam strip will expand to fill the gap
  - The closer the opening to the windows size
  - The more compressed the strip remains
  - Weather and wind tightness, acoustics and thermal performance possible

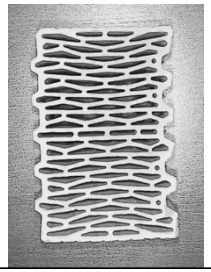
Thermal Insulation Materials

Mineral Insulations

Fired clay

Extruded Block:

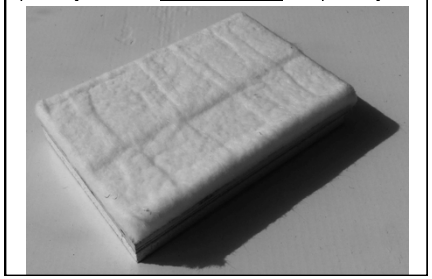
cellular and long pathways



Extruded Fired Clay Block

- Like bricks only much more
- Clay with sawdust that burns off
  - Many small air bubbles throughout clay
- Extruded with many air pockets
  - Small section to minimise eddy currents
- Solid parts create a long pathway from one side of block to the other
- Better k value than filed clay brick
- Better actual performance

Aerogel with Mineral Fibre



Aerogel

- Silica in solution, water removed
  - Leaving silica matrix and
  - Microscopic air bubbles
  - Added fibres to reinforce quilt
  - k values better than the best plastic insulation
  - Micro porous
  - Good fire performance (some tested)

Aerogel in Paint

Aerogel in Paint

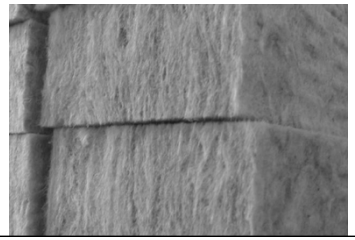
- Government Magic wand!
  - Insulating paint
- 1 mm of Aerogel not a good U value
- It's a small improvement in thermal comfort
  - But mostly to the touch only

Glass Mineral Fibre

Glass Wool

- Middle of the road k value
- No decrement delay at normal density so exacerbates summer overheating
- Combustible?
- Hydrophobic: No moisture management
- Only use in vapour closed thermal construction
- Used for acoustics a lot

Stone Mineral Fibre

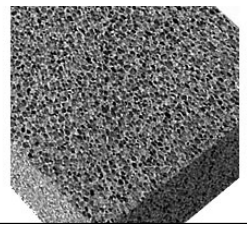


Stone Mineral Fibre

- Its Cheap and large market share
- Created from abundant natural resource (stone)
- Also uses Pumice (volcanic rock, renewable but not abundant)
- Saves in-use winter energy (so do all insulation materials)
- No Decrement delay at thermal insulation densities so exacerbates summer overheating
- Offers no solar radiation heat gain protection in summer
- Uses more embodied energy to make it
- Recyclable (after many years of use but also degrades with brittleness so not reusable)
- Hydrophobic (repels water so water is held in air spaces so cannot insulate, can hold water against timbers)
  - Nicknamed by greenies: Rotwool
- Fire resistant densities:
  - Non-combustible
  - Used in fire resistant assemblies
  - Almost unique in rainscreen cladding thermal insulation (post-Grenfell)

Cellular Glass (CG)

Foamed into slabs and boards or nuggets for aggregates



Cellular Glass boards

- The use of Foamglas on British Library Euston (BLE) was extensive
- Non-combustible in a Section 20 building
  - High rise, large m2, public assembly
- Applications: next slide

It was used in: (BLE)

- Basement perimeter wall internal gutters with asphalt
  - Foamglas slabs T2 or T4 (thermal) (no paper surface)
- External Cavity walls partial fill
  - Foamglas wallboard T2 or T4 (thermal) (papered surface)
- Forecourt waterproofing with asphalt or high performance felt
  - Foamglas S3 (structural) and Foamglas slabs T4 (thermal)
- Flat roofs asphalt
  - Foamglas slabs T4 thermal (no paper surface) in hot bitumen flood coat
- Floor insulation under screeds
  - Foamglas slab S3 (no paper surface)
- Exposed floor soffit insulation
  - Foamglas T4 Aluboard (aluminium foil faced)
- and many other details
- But not outside of the basement wall or basement suspended lowest floor.

Application

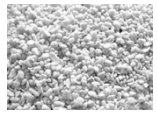
- In all cases the intention was for:
- Bonded to inner leaf and fully filled joints in (paper or foil surfaced) boards to walls and soffits: 2 part adhesive
- (not papered surfaced) slabs in bitumen flood coat to asphalt roofs, gutters and waterproofing to ensure joints filled and tops are squeegeed with excess bitumen, followed by protective/ waterproof membranes.
- In all cases the insulation was protected from moisture ingress and frost damage, even though the insulation itself is water and vapour proof.

Precautionary principle (BLE)

- Despite Foamglas being a waterproof and vapour proof material
- BLE did not rely on this and always protected it from water
- treated it as a 2nd or 3rd line of defence in construction on a building with up to 500 year design life for basements and 250 years for superstructure 120 years for external envelop. (BLE)

Expanded mineral insulation

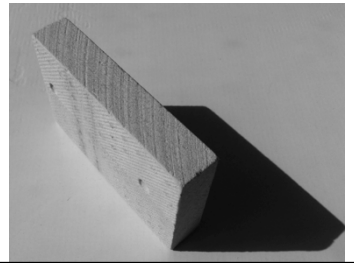
Expanded perlite insulation



Expanded Perlite

- Expanded or Exfoliated?
- Mineral
- Thermal and Fire performance

Calcium Silicate Expanded mineral insulation



Calcium Silicate

- Invented for historic building fabric external masonry walls
- Aerated mineral matrix board
- IWI Internal wall insulation
- Bonded direct to internal surface
- Moisture permeable
- Controls prevents condensation mould

Autoclaved Aerated concrete

Autoclaved Aerated Concrete AAC Aerated Concrete AC

- Steam cured concrete: energy intensive
- Binder: OPC Cement matric
  - High Energy High Carbon
- Aggregate: Sand or fine aggregate
- Aluminium oxide: Saponification bubbles
- Format: AAC block or wall slabs
- Format: AC insitu concrete
- AAC: Internal wall or partition, wall panel
- AC: self insulating ground floor slab

Animal

Sheep's Wool

And goat hair

Hygroscopic Insulation: Sheep's Wool

Sheep's wool

- When on the sheep's back they are kept warm in winter and cool in summer
- Hygroscopicity absorbs moisture into fibre and the insulating action is maintained
- But also in summer moisture loss has cooling effect and in winter moisture gain has warming effect

Sheep's wool: Cool in Summer

- When outside temperature increases and begins to heat sheep's wool, it releases moisture;
- has a cooling effect on the fibre which reduces the flow of heat to the inside of the building
- Can reduce peak temperature by up to 7°C compared to alternative insulation

Sheep's wool: Warm in Winter

- In the winter the absorption of moisture by sheep's wool insulation
- can increase peak temperature by up to 4°C
- when compared to buildings in which alternative forms of insulation are installed.

Bird feather

Eider down

Bird feathers

- Used in bedding quilts
- Crate still air pockets
- Quilts need drycleaning but cost more to clean than buy new
- Big waste stream to divert from landfill
- Interreg Project investigated converting into construction thermal insulation

Plant fibre

Hygroscopic Thermal Insulation

Newspaper
Flax
Hemp
Sheep's wool
Cellulose

Construction Resources Showroom

Coconut Husk Fibre

Plant fibre - Essence

- Dried fibres minus essence
- Loose, Batts, Quilts, Boards
- MOR k value similar to Mineral Wool
- +Specific Heat Capacity: High
- +Density provides Decrement Delay
- Good winter and summer performance

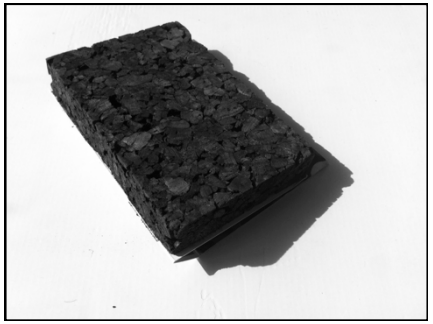
Plant Fibre

- Cork Bark
- Hemp shiv
- Flax stalks
- Straw stalks
- Straw board
  - (Strammit: Not compatible with UK Climate)
- Grass cuttings
- Cotton (but water & chemical intensive)
- Denim (ditto)
- Many more

Cork

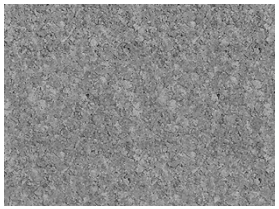
Loose, Boards, Tiles,

Added to plaster



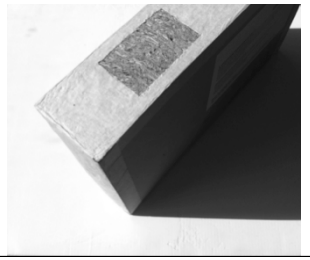
Cork: Tree Bark

- Portugal, Seasonal production, harvested for limited number of years
- Tree based: Bark and binder
  - Carbon Sequestration
- Binder: can be combustible, flammable initially
  - But the cork will char like timber and become fire resistant
- Many formats:
  - Loose: Chips
  - Rigid: board, sheet,
  - Flexible: floor tile
- Decrement: Radient Thermal Insulation
- Hygroscopicity: Moisture Management
- Chipped: Added ingredient in renders



Cork: Floor tile

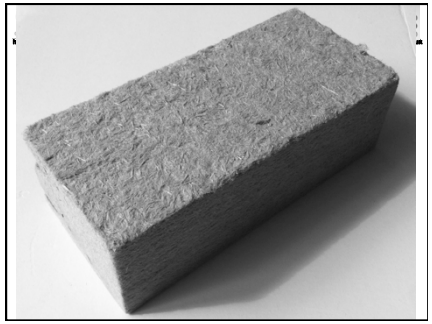
- Portugal, Seasonal production, harvested for limited number of years
- Tree based: Bark and binder
  - Carbon Sequestration
- Flexible: floor tile: Thermal comfort on feet
  - 2-3 mm thickness: good k value, poor U value
- Decrement: Radient Thermal Insulation
  - If laid on concrete it can be warmed through cork tile
- May get a surface sealer preventing Hygroscopicity
  - Hygroscopicity: Moisture Management?



Strawboard

- 50 mm thick panels
- Compacted straw
- Paper surface all round
- Good k value for winter
- Good Decrement factor for summer
- Goof fire performance (doors, partitions)
- Good Acoustics (Partitions roofs walls)
- Not good in UK climate: any grains can grow and board expands
- Disappeared from UK market 1970's
- R&D at Brunell University trying to solve it
- Very effective in other dryer climates

Wood fibres



Woof Fibre Batts or Slabs

- Recycled wood fibre milling waste
- Suitable insulation in, above or below:
  - Framed Walls, Roofs, Floors
  - Solid Masonry: IWI with clay and EWI with lime render
- High acoustic density
- High decrement delay
  - (Specific Heat Capacity, Density and k value)
- k value worse than rock,
  - Increased thickness needed
- Phenomenal summer performance compared to:
  - glass/rock mineral fibre
  - expanded polystyrene plastics insulation

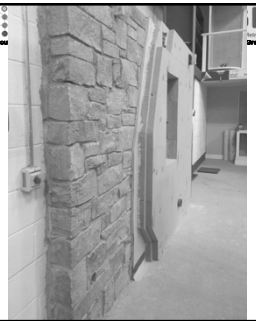
Dense wood fibre rigid board

- Wet or dry manufacturing process
  - Lectin released and used to bind fibres
- k value little worse than stone wool
  - Greater thickness needed for winter
- High decrement delay: good for summer
- Hygroscopic:
  - good for moisture management,
  - use in vapour open construction
- Rigid: can span between framing
- Versatile applications:
  - Roofs Walls Floors
  - Inside or outside framing

Wood Fibre Systems

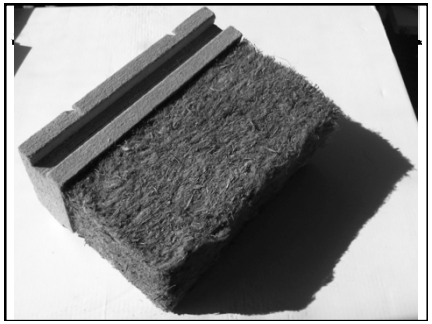
Dense wood fibre (DWF) systems

- Original inventers or DWF
- Continuously inventing whole systems
- Versatile applications:
  - Roofs Walls Floors
  - Inside or outside framing
  - IWI & EWI
- Purpose made ‘Systems’ including accessories and finishes



Dense wood fiber systems

- Stone walls lumpy profiles
- Rigid boards would create cavities
  - Where moisture cannot jump cavities
  - Moisture stops at cavity
  - Will reactivate any spores in the cavities
  - Mould can grow undetectable
- Vapour permeable adhesive bonded to stone wall, no more cavities
- Moisture transport across wall restored
- Vapour open system

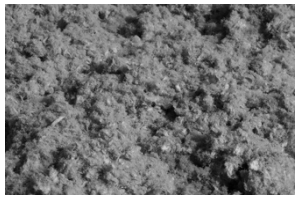


Wood Fibre Rigid & Soft Insulation

- Stone walls lumpy profiles
- Rigid boards would create cavities
  - Where moisture cannot jump cavities
  - Moisture stops at cavity
  - Will reactivate any spores in the cavities
  - Mould can grow undetectable
- Compressible insulation on back face mould to lumpy profiles of stone wall, no more cavities
- Moisture transport across wall restored
- Vapour open system

Cellulose Fibre

Recycled Newspaper
Recycled Magazines

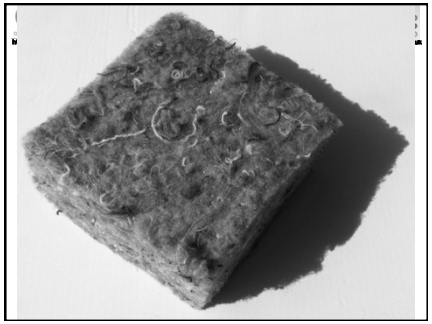


Cellulose Fibre Flake

- Recycled newspaper/magazine
- Cellulose fibre flake insulation in:
  - Framed Walls, Roofs, Floors
- High acoustic density & high thermal mass whilst k value similar to rock
- Phenomenal summer performance compared to:
  - glass/rock mineral fibre
  - expanded polystyrene plastics insulation

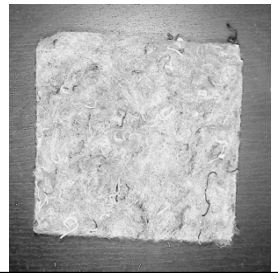
Recycled Cloth Insulation

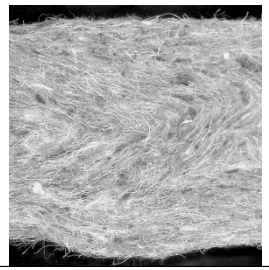
Recycled denim



Recycled Denim

- Matisse from France
- Available in UK
- Denim clothes shredded
- Batts
- Hygroscopic: Moisture management use on vapour open construction
- Some thermal mass
- Used in framing zone of lightweight timber frame (LTF)





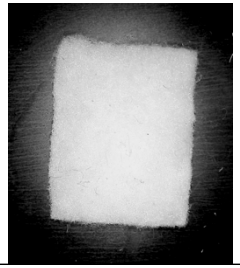
Recycled Tweed

- Made in Scotland
- Tweed clothes shredded
- Batts
- Hygroscopic: Moisture management use on vapour open construction
- Some thermal mass
- Used in framing zone of lightweight timber frame (LTF)

Plastic Insulation

Plastics

- Potentially less materials
- Potentially better winter performance
- Potentially worse summer performance
- Specification, detailing and Installation workmanship undermines performance
- Gappy insulation is very ineffective
- BRADL has been updated to force use of GapOTape or equivalent



Polypropylene

- 'Non-itch' marketed as an improvement over glass or stone mineral wool
- Finite resource: Petrochemical, hydrocarbon, oil bi-product
- Fossil Carbon: Adds to Climate Change
- Plastics manufacturing generates:
  - 4.5% of man made CO2
  - And lots of heat energy and its CO2
- Hydrophobic, Moisture impermeable:
  - use in vapour closed construction
  - Incompatible with historic building fabric
- No Decrement Delay: can exacerbate overheating
- Applications:
  - Can't think of any useful competent appropriate applications
  - Promoted as a replacement for glass and stone wool I remain unconvinced

Multi Foils

Radiation & Reflection

- Multi-foil insulation rolls exploit these characteristics
- Many layer of metalised plastic foils and expanded polyethylene sheets bound together by stitching
- Use of surface resistivity relies on cavities of air space
- Outwards
  - Reflects heat back in
  - Insulates between reflective foils
  - Does not conduct heat outwards
  - Does not radiate heat outwards
- Inwards
  - Reflects solar heat back out
  - Insulates between reflective foils
  - Does not conduct heat or coolth inwards
  - Does not radiate heat or coolth inwards

Controversy

- Manufacturer claims 19 mm. is equivalent to 250mm. of rock mineral fibre
- BSI's Hot box test method does not support this claim
- Whole house tests do allegedly
- AECB challenge: manufacturer trying to prove it
- Dropped the existing product and created a new one with one more layer loosing all the baggage
- Check their figures

Foamed Plastics

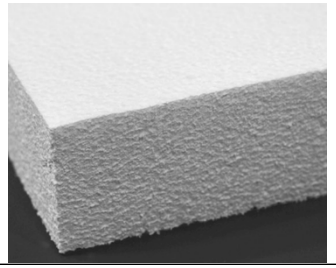
EPS Expanded Polystyrene,
XPS Extruded Polystyrene,
PIR, PUR Polyurethane,

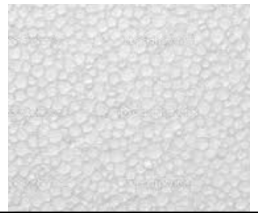
Expanded Polystyrene (EPS)

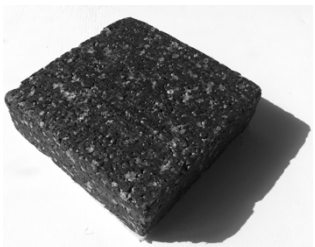
- Finite resource: Petrochemical, hydrocarbon, oil bi-product
- Fossil Carbon: Adds to Climate Change
- Plastics manufacturing generates:
  - 4.5% of man made CO2
  - And lots of heat energy and its CO2
- Hydrophobic, Moisture impermeable:
  - use in vapour closed construction
  - Incompatible with historic building fabric
- No Decrement Delay: can exacerbate overheating
- Applications:
  - Below Ground floor thermal conductivity insulation
    - Protected by Damp Proof Membrane (DPM)
  - Inverted Flat roof construction? multi-layered to minimise cold bridging
    - Needs decrement delay somewhere in the roof element

Extruded Polystyrene failures

- Below Ground Insulation
- Wet and failed extruded polystyrene,
- 3 reported instances of this, 2 in Belgium and 1 in France and all on Earthships.
- Every building material suffers from failure if badly installed or installed outside manufacturers standard details.
- In all the cases, failure was due to poor waterproofing and freeze thaw degradation of the material.
- In the cases investigated, the contractors had failed to install either a waterproofing layer or where the board product was used, had cut corners by not using any sealant on the joints.







Recycled Expanded Polystyrene (REPS)

- Finite resource: Petrochemical, hydrocarbon, oil bi-product
- Fossil Carbon: Adds to Climate Change
- Plastics manufacturing generates:
  - 4.5% of man made CO2
  - And lots of heat energy and its CO2
- Recycled content, Or Graphite added
- Hydrophobic, Moisture impermeable:
  - use in vapour closed construction
  - Incompatible with historic building fabric
- No Decrement Delay: can exacerbate overheating
- Applications:
  - Below Ground floor thermal conductivity insulation
    - Protected by Damp Proof Membrane (DPM)
  - Inverted Flat roof construction?
    - multi-layered to minimise rainwater cold bridging
    - Needs decrement delay somewhere in the roof element

Rubber Insulation

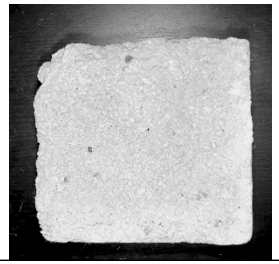
Latex Foam

- Invented by mould growth consultants to remove risk of surface condensation in fuel poverty stricken houses
- IWI Internal wall insulation
- Provides the barest minimum of thickness and allows wall papering over
- Offers a degree of thermal comfort
- Thin, okay k value, poor u value
- Same materials as Spitting Image puppet heads

Mixed materials

Papercrete

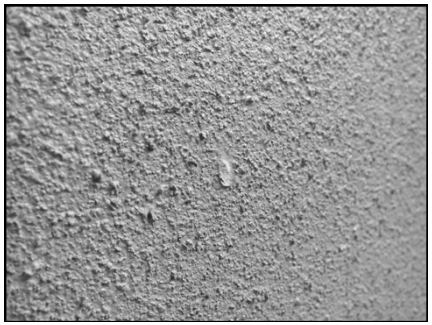
Cement and Paper making fibre sludge
GGBS OPC replacements ideally



Papercrete

- Paper making waste sludge fibres
- Cementitious binder
  - OPC Ordinary Portland Cement
  - Could be GGBS Ground Granulated Blast Furnace Slag cement
  - Could be blended OPC & GGBS
- Very low density
- High thermal mass: Decrement Delay?
- OPC is water and vapour resistant
- Paper sludge fibres are vapour permeable
- How vapour permeable if the end result?
- Strength: ? Similar low strength Hemp-lime blocks
- Connected two companies to try to bring something to market

Cork Diamaceous Earth Render



Diatomeic Powders, Cork, Clay and Lime Plaster/Render

- IWI Internal Wall Insulation or EWI External Wall Insulation
- Premixed thermal plaster
  - Ocean floor minerals: Diatomeic Powders
  - Cork granules: 0-3 mm
  - Hydraulic Lime: NHL 3.5
  - Clay
- Vapour permeability: $\mu = 4$
  - Breathable: compatible with historic walls
- Capillary water absorption: 0.35 kg/m2.hr (Category W2)
- Fire: Euroclass A2
- Sound absorbing coating
- k value: 0.045 W/mk Winter Insulation
- Density: 360+/-20 kg/m3
- Decrement delay: Summer Insulation
- Inert and recyclable
- Indoor Air Quality: Low VOC emissions
- Manufacturer: Diasen
- Product Reference: Diathonite Evolution

Hemp-lime

Hemp-lime Hempcrete

- Hemp shiv fibres
- Rapidly renewable plant fibre
- Lime binder
- Very low density
- High thermal mass: Decrement Delay?
- Lime is water and vapour permeable
- Hemp shiv fibres are vapour permeable
- How vapour permeable if the end result?
- Strength: ? Similar low strength Hemp-lime blocks
- NGS Connected two companies to try to bring something new to market with a new non-cementitious binder

Hemp Lime Applications

- Insitu spray on to walls
- Insitu spray into cassette panels
- Insitu compact into diaphram wall cavity
- Insitu ground bearing floor
- Non-loadbearing blockwork
- Loadbearing blockwork ? Add cement?

Tradical Hemp-lime Hempcrete

- Hemp shiv fibres
- Rapidly renewable plant fibre
- Lime binder: Slow set, softer bond, high energy, high carbon
- Cementitious binder added to drive the lime's hydration
  - OPC Ordinary Portland Cement, fast set, strong bond, very high energy, very high carbon
- Aluminium oxide: saponification reaction with cement generated bubbles
  - Bubbles add thermal insulation
- Phase Change characteristic
- Very low density
- High thermal mass: Decrement Delay
- Lime is water and vapour permeable
- OPC is water and vapour resistant
- Hemp shiv fibres are vapour permeable
- How vapour permeable if the end result?
- Strength: ? Similar low strength Hemp-lime blocks, very low strength
- Manufacturer: Lhoist
- Product Reference: Tradical

Lightweight Cob Clay-Straw

Interreg CobBauge Project

- Cob=English, Bauge=French
- Earth (Clay recipe) and straw
- 21st Century Cob (Regulations)
- Traditional Cob is Structure, Thermal mass and weather exclusion
- CobBauge combines: (see previous slide)
  - structural mix cob (yellow) with
  - light clay straw/hemp insulating mix cob (brown)

Mixed materials Multi-component systems

SIPs Structural Insulated Panels

Structural Insulated Panels SIP

- OSB Oriented Strand Board skins
  - Biobased but added chemistry binder
- PUR Polyurethane
  - Non-renewable fossil fuel bi-product
  - High carbon: adds to climate change
  - Toxic in fire
- Panel jointing adhesive: more chemistry
- Good k value for winter
- Poor decrement factor for summer
- High risk of overheating in summer

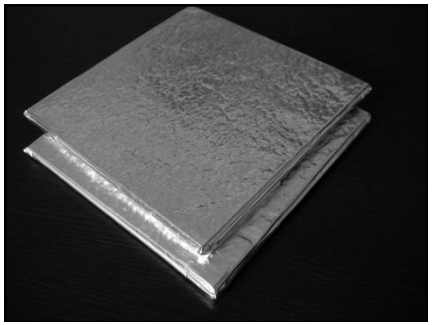
ISPs Insulated Structural Panels

Structural Timber cassette panels any insulation fill

Insulated Structural Panels ISP

- Plywood, chipboard or OSB skins
  - Biobased but added chemistry binder
- Any insulation ideally biobased
  - Rapidly renewable agricultural bi-product
  - High Sequestered carbon: reduce climate change
  - Hygroscopic: Moisture management
- Dry Panel jointing or taped joints
- Good k value for winter
- Good decrement factor for summer
- Low risk of overheating in summer

Vacuum Insulated Panel VIP

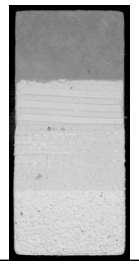


Vacuum Insulated panels VIP

- Aluminium Foil envelope
- Plastic spherical balls accurately packed with 12 points of contact between each
- Air sucked out of envelop
- Vacuum in interstices between spheres
- Best ever thermal insulation k value
- No decrement delay
  - Sun's heat passes through vacuum of space without hindrance

Lightweight Thermal Mass

- Dense wood fibre outer layers
- Cardboard honeycomb core
- Cardboard cells contain wax
- Phase change materials (PCM):
  - Phases: Solid, Liquid & Gas
  - Fluidity: ability to move between phases
  - Changing phases: gains or released heat energy
  - Wax stores or releases heat energy
- Adds thermal mass to partitions and freestanding screens
- 22:26 Austria: Suggestion
  - Reduce 700 mm extruded clay walls to 500 mm
  - Add back lightweight thermal mass IWI



Wood Fibre based Systems

- IWI: Wood fibre board with moisture permeable plaster skim
- EWI: Wood fibre board with moisture permeable lime render

File Updates

Rev No.	Comments	Author	Date
A01	First created, up to revision 93	BRM	10/03/2007
A02	GS to GBE Logos, Rev Table added, major update for GBE CPD @ MMA	BRM	01/07/2023-03/07/2023
A03	Added more scanned sample images	BRM	04/07/2023
A04	After CPD added more text, slides, etc. Posted on GBE website	BRM	06/07/2023
A05		BRM	03/07/2023
A06		BRM	03/07/2023
A07		BRM	03/07/2023
A08		BRM	03/07/2023
A09		BRM	03/07/2023

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- Launched www.greenspec.co.uk 2003
- Created: GBE at https://greenbuildingencyclopaedia.uk 2012 – 2022
- Created: GBL Learning: https://GBELearning.com 2020 - 2021
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