LCGB: Low Carbon Green Buildings

Brian Murphy (GreenSpec)

Issues

- Low carbon Buildings
- Heavyweight v lightweight
- In manufacture/construction & use
- Insulation Airtightness & Cold bridges
- Insulating the less obvious elements
- Heating, DH&CW, Cooling & Ventilation

2

Issues

- UK lessons
  - Party Walls
- Passivhaus lessons
  - PHPP v BRE SAP
- AECB research
  - Moisture and energy consumption
  - CLP & Website
  - Windows and thermal comfort

3

Issues

- **Climate Issues**
- Radiant heat in coming summers
- Solar heat gains
- Solar shading
- Thermal Mass
- Ventilation and cooling

Issues

- High Performance Natural materials
- Characteristics:
  - Carbon Sequestration
  - Decrement & radiant heat
  - Hygroscopicity & performance
  - Breathing walls

5

Issues

- Code for Sustainable Homes
  - Level 4 5 & 6
  - Materials Scores
    - Elemental deficiencies
- BRE Environmental Profiling
  - Methodology & data deficiencies
- BRE Green Guide to Specification
  - Elemental deficiencies

6

Elizabeth Fry Building UEA

Elizabeth Fry Building

- **Was one of the most energy efficient buildings in the UK**
- **Resource efficient: co-ordinated design, little cutting waste**
- **Low budget:, everything had double functions, worked much harder**
- **Integrated multi-discipline design essential**

Windows:

- **view, natural daylight, natural ventilation**
- **Double casement:**
  - acoustic/thermal insulation, easy maintenance
- **Enclosed blinds:**
  - solar control, privacy, easy maintenance

Floors:

- concrete plank:
  - **Load-bearing, acoustic,**
- exposed soffit:
  - **thermal mass, no ceiling**
- hollow core
  - **mechanical ventilation**

Lighting:

- **Perimeter lighting**
  - Avoids fixing to soffit
- **Pelmet**
  - Hides curtains and lighting
- **Mechanical ventilation**
  - Passes over lights
  - Removes heat
  - Heat recovered for other uses

Modular Design

- **Blocks and Windows coordinate**
- **No cutting no waste**
- **Hiccup details: change of materials**
- **Whole paving slabs: no cutting no waste**

Commercial Green

- **Commercially viable products, materials and systems**
- **Market & supply chain sufficiently well developed**
- **Prototyping stage over**
- **Products developed matured refined and price competitive**

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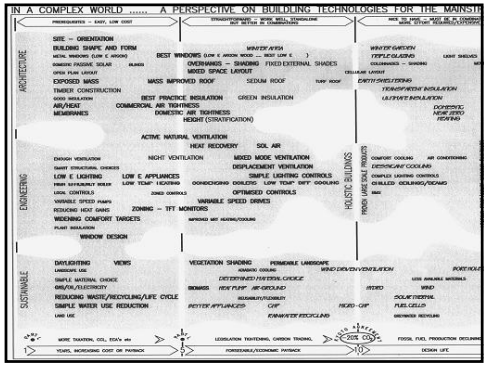

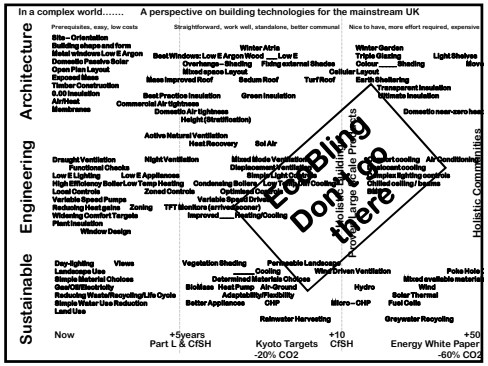

BDA & BedZED

- **Climate Neutral Toolkit: in use Zero Carbon Emissions, Low impact in production**
- **Buyers Club**
  - Bulk buying discounts
- **ZEDfactory > ZEDproducts**
  - Building Fabric, FFE,
- **ZEDfabric(ations) whole house systems**
  - PV, ST, ActiveVentilation, etc.
- **Finance available**
  - Repayments = normal monthly fuel bill

BioRegional One Planet Products

- Spin off from BedZED
- Low impact lifestyle products
- Potential scope:
  - Low energy & water use White Goods
  - Low water use sanitaryware: WCs, Taps
  - Electric Car, Electric Scooter
  - etc.
- Buying club
  - Quantity Discounts

Costs

- GreenSpec has 'at factory gate' product cost
- Industry position or club dictates discounts
- Factory gate to site dictates transport costs
- Project dictates complexity and waste factor
- Complexity adds to labour cost safety margins
- Unfamiliarity beefs up safety margin
- Only use approved applicators/installers with prior knowledge for competent tender

Supply Chain Logistics

- One distributor/stockist
- Many satisfied contractor customers
- Many products on GreenSpec to assess if accessible
- Commitment to buy, stock, supply and sell any green product from GreenSpec?
- Hook up GreenSpec product page with buying/ ordering website
- Guaranteed supply chain
- Confidence to choose products
- Commitment to specify and not substitute
- Prices tumble

CO_2 and Carbon reduction

- Do not limit to complying with Building Regulations Part L1A
- Set out to exceed Kyoto, EU or UK CO_2 targets
- Reduce heating demands towards zero
- Windows: U value of 1.0 W/m2.K or better
- Walls: U value of 0.1 W/m2.K or better
- Airtightness: less than 1, not 10 of Building Regulations
- Thermal mass to capture and exploit solar gain

Renewable Energy

- Renewable heat energy and solar thermal panel to heating and hot water
- Passive solar gain with some east, south and more west facing glazing
- Summer solar shading, winter solar access
- West, south and east posititioned thermal mass to collect heat and high level to store

Energy Efficiency

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- Grade A, A+, A++ Electrical Appliances,
- fittings,
- luminaires
- everywhere,
- no standby mode

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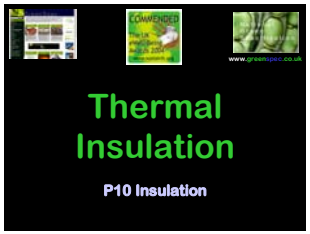

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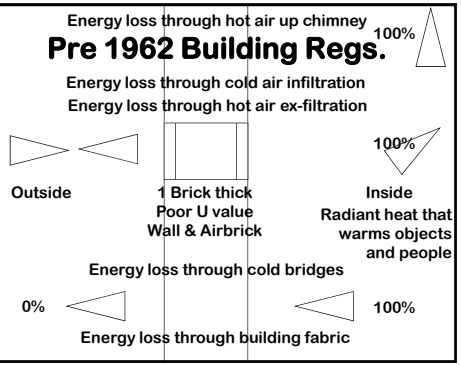
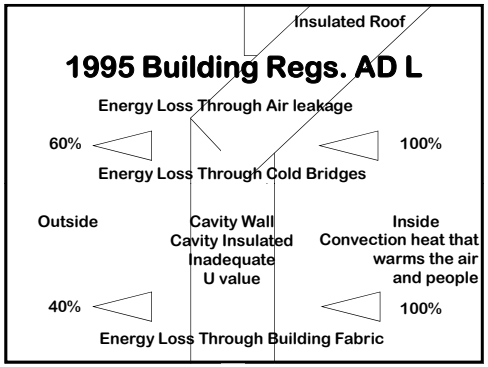
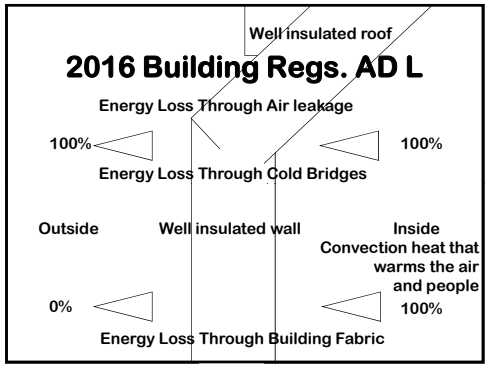
Thermal Insulation:

- Insulation, Insulation, Insulation
  - Understood technology, value underestimated
  - Poor workmanship, lack of care
- Airtightness
  - Early days lots to learn by all concerned
  - Design and workmanship
  - Lack of understanding of importance is widespread
- Cold Bridges, convection and stack effect
  - Understood but compromise is too easy
  - Lack of understanding of importance is widespread
  - Design primarily don't rely on workmanship to fix detail







Don't insulate very old buildings!

- If the old building has an open fireplace and airbricks and leaky windows (all as originally designed)
- all the fire's heat is radiant and warms objects and people in the room, not the air, outdoor cool air is drawn in through the gaps and is driven up the chimney by the buoyancy of the heat of the fire.

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Cold air & radiant heat

- The room air never gets very warm so insulating the building is a bit fruitless as there is no warm air to keep in.
- The external wall do not need insulation either as there is no warm air to keep in.
- Radiant heat may warm the surfaces of the walls and ceilings and that heat may radiate back to the occupants when the fire is out,
- but is just as likely to be conducted outwards.
- External insulation may help but the fire needs to be on continuously for a long time to warm up the walls.

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HOWEVER

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- The minute you change the heating system to close the open fireplace and/or close the air bricks and/or change or modify the windows to be high performance low leakage rate, everything changes.

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Warm air needs insulation

- As soon as the air is warmed (for example by a water based panel radiator system using convection to heat the air) then insulation becomes vital.
- The warmed air will rise to the ceilings and attempt to pass to the attic and escape, insulation will keep it in, then the warm air builds up in the space and then the walls need to be insulating too, eventually even the room's floor needs insulation.

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Make tight, ventilate right

- Now that the building is airtight it needs to ventilated deliberately for people and for the heating system unless it is a balanced flue.
- Deliberate ventilation must have heat recovery to be useful and not waste the heat that has been created.

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Conservation Quality Buildings

- Conservation officers often prevent modification of old buildings for energy performance purposes
- I used to argue all you can do for these buildings is insulate the loft and get Ground (or air) source heat pumps to provide heat
- but this argument kind of scuppers that.

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Comfort conditions

- Cold surfaces make uncomfortable rooms to be in
- Warming up surfaces makes a space more comfortable
- Radiant heat and surfaces backed up by insulation will help to keep the surfaces warmer.
- So insulate them after all
- Insulate any cavity in internal walls and floors as well

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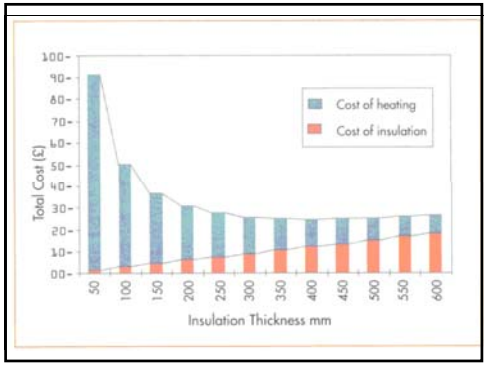
Insulation

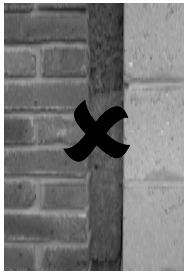
- Insulation, Insulation, Insulation
- Spend money on insulation, its cheap
- Save money on heating and cooling plant, its expensive
- Save money on heating and cooling bills it will get more expensive over time
- 'Peak oil' has been passed



50 mm. cavity is history

300 – 600 mm. is optimum

Ties and tie spacings may change



BedZED Beddington Sutton Architect: Bill Dunster

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 HFA foamed plastic
O_3 Ozone Depletion
Greenhouse Gas Potential
300-600 mm. optimum insulation thickness

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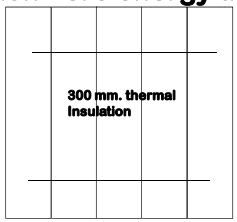
U Values of 0.1 W/m2.K approach Zero energy demand



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

Cellulose Fibre: Thermal Mass

- High acoustic density & high thermal mass
- cellulose fibre insulation boards in:
  - **Walls**
  - **roofs**
- Phenomenal performance compared to:
  - **glass/rock mineral fibre**
  - **expanded polystyrene plastics insulation**

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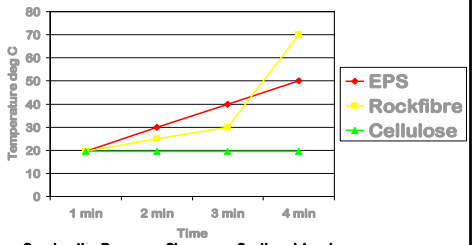
Radiant heat through 50 mm. of thermal insulation types over time



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Decrement (Thermal Inertia)

- Energy passes through walls and is slowed by lightweight insulation
- Dense thermal insulation can store heat in the insulation
- Foamglas an example
- Dense cellulose fibre can do the same
- Will stop solar radiant heat in itself for longer then mineral fibre and EPS
- 1970's understood but not generally exploited

Another GreenSpec CPD seminar to download soon

Another GreenSpec CPD seminar to download soon

% heat loss

- As Insulation Standards rise
- The % heat loss through the fabric reduces
- The corresponding % of heat loss through air leakage increases
- All the more important to fix air leakage

Air Tightness

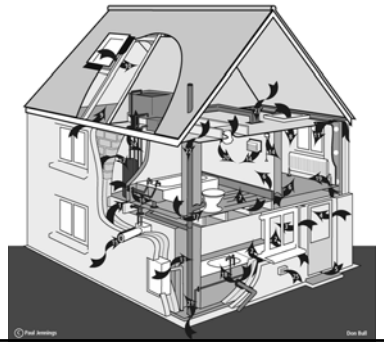
- In past related to:
  - Windows and doors, air bricks, fire place
  - Ground Floor Floorboards
  - Roof spaces (except Scotland, boarded)
- Now relates to:
  - Inadequately designed building details
  - Badly built building fabric
  - Due to lack of understanding or training
  - Poor workmanship
- Good workmanship cannot fix bad details

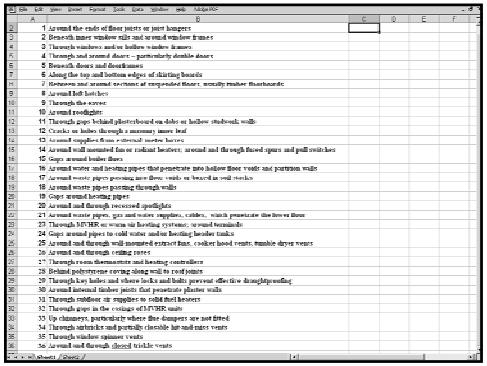
On-site Airtightness Testing

- Seal up the building openings
- Pump air in
- Reach a preset +ve pressure
- How much air is needed to maintain the pressure?
- = Air leakage rate
- Building Regulations permit 10, we struggle to achieve it
- 8 is a leaky building unusable in windy weather, due to air noise and drafts
- Europeans aim for 3, 2, 1 and better down to 0.3-0.1

Vulnerable details

- Skirting:
  - Where are the slip layers and vapour barriers?
  - Do they lap and are they bonded?
- Floor level:
  - Do joists bear in walls how are they sealed?
  - mortar shrinks, consider joist hangers
- Light fittings:
  - Are they sealed or just a hole?





Timing of testing

- Has an impact on construction sequence and programme
- Building structure and building fabric
- Envelop substantially complete
- No finishes yet
- Test and fix leaks in the structure and fabric
- Then complete with the finishes
- All sealants hidden behind finishes
- No cavities behind linings to complicate leak detection and tracking to source

Sealants?

- Use to seal the leaks?
- Benign type of sealant?
- Linseed oil putty is natural plant extract
- Natural solvent and natural VOC
- Oils do not normally leach out into porous absorbent materials
- Other sealants are synthetic: solvents, VOCs, lick hazard
- Primer/sealer: control leaching

Foamed insulation?

- Use to seal the leaks?
- Petrochemical: non-renewable
- Blowing agent: ZODP Zero Ozone Depletion Potential essential
- Many HCFC blowing agent, bad news
- H&S: Hazardous content and waste
- AECB experience suggests they shrink after a short period of time and fail

Air leakage

- Building Regulations Approved Document:
  - L1A, L1B, L2A, L2B Thermal Insulation
    - 'Not so Robust' Accredited Construction Details
    - Thermal insulation avoiding Cold bridging
    - Airtightness? Possibly
  - E Acoustic Insulation of internal compartment & party walls
    - Robust Details: Acoustic detailing
    - (contributes to airtightness if addressing external compartment and/or party walls)

Brown envelopes

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- Not much use for filling gaps
- Just perpetuate the problem of leaky buildings
- Be there when the test is being carried out
- Be sure

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Cold bridges

- Not normally an air passage out through construction but a thermal conduction route
- Usually solid materials with low insulation performance in contact with each other
- Forming a chain from inside to outside
- Usually load-bearing elements

Cold bridge solutions

- Plastics/rubbers in aluminium extrusions in windows and curtain walling
- recycled glass load-bearing thermal insulation into base of load-bearing walls
- E.g. Foamglas Perinsul
- Insulating blocks at ground floor slab level

Acoustic Insulation

P10 Insulation

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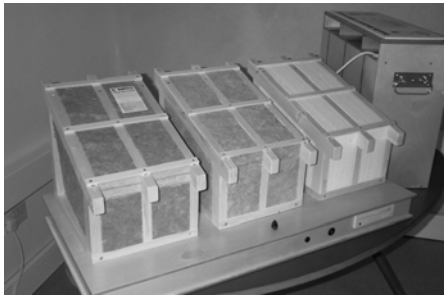

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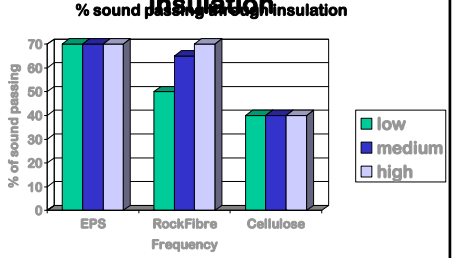
% of sound passing through insulation



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Acoustics

- Ventilation in urban areas conflict with quiet in homes and offices
- Airtightness Contributes to Acoustic performance

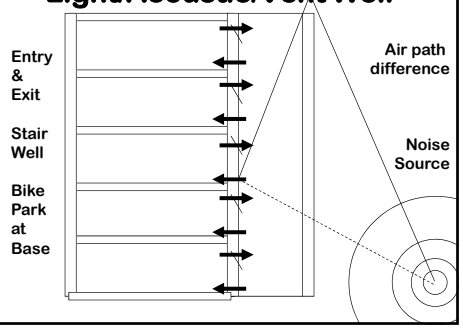
Robust & Accredited Details

- Thermal: 'Robust' they are not
- Thermal: 'Accredited' they are now
- Thermal: Inadequate they remain
- CLP CarbonLite Programme will generate zero energy details
- that may become Accredited Details alongside the existing
- but will work unlike the existing

Nat Vent/Acoustic Wells

- Urban areas with high traffic noise create problems for natural ventilation of buildings
- Wells within the building offer long air path difference acoustic performance and an opportunity for natural ventilation from rooms to the well
- The well may include staircases
- Discourage them as smoking places

Light/Acoustic/Vent Well



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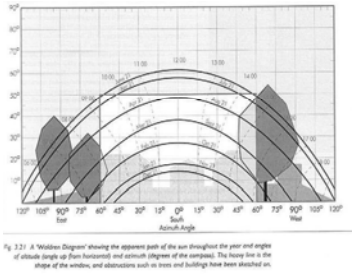
Solar Orientation

- Where do you put the conservatory and windows for optimum solar gains and minimise overheating?
- Where is the optimum position and orientation for solar thermal panels?
- Can the early morning winter sun thaw out the car in time to go to work?
- Can you locate the car to enable this?

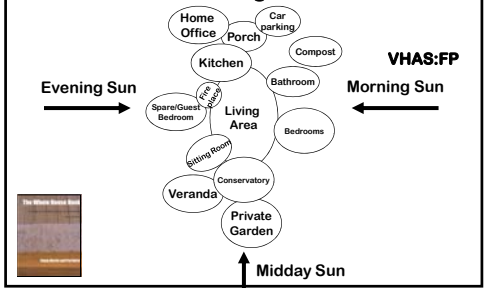
Waldren Diagrams & Scopes



Sunlight

- East morning light cooler
- South facing hot: exclude if you can
- SW facing hottest: as afternoon continues to pile on heat
- West evening light: warm beneficial into the night
- Permit entry when not hot
- Rooflights act like sundials
- Sun pipes are a last resort for poor design or retrofit

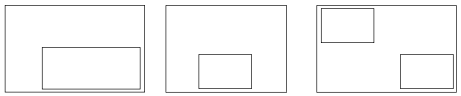
Basic Room Relationships: Detached house & Traditional Thinking Solar Orientation



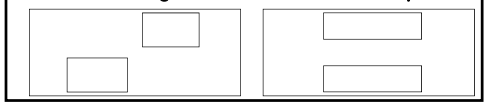
Wall Surface Area:Footprint

VLWSA:FP	MWSA:FP	HWSA:FP	VHWSA:FP
Large plot, High density difficult, Expensive to build, Inefficient to occupy, Cheap to heat, Generates high waste	Small plot, High density Easy, Cheap to build, Efficient to occupy, Economic to heat, Potentially High or low waste	Large plot, High density Difficult, Economic to build, but expensive corners/diag, Inefficient to occupy, Uneconomic to heat, Generates high waste	Large plot, High density Difficult, Uneconomic to build, Potentially easy to occupy, Uneconomic to heat, Potentially High or low waste

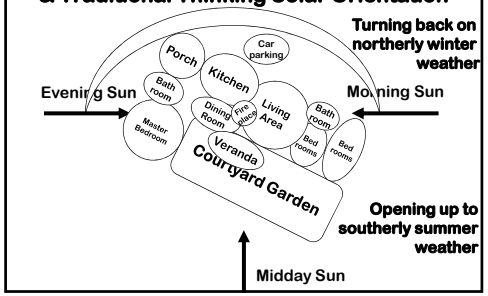
Courtyard House Plans



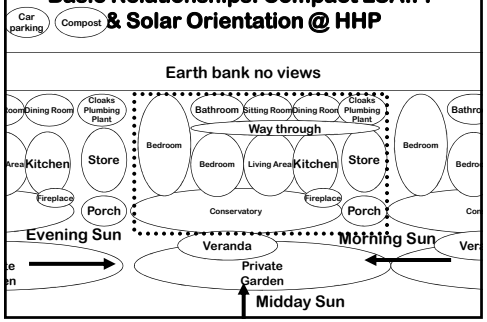
Solar gains via courtyard glazing
Heat losses via glazing to courtyard
Sheltered courtyards and glazing less loss by cold wind
Well insulated longer external walls & windows important



Basic Room Relationships: Courtyard House & Traditional Thinking Solar Orientation

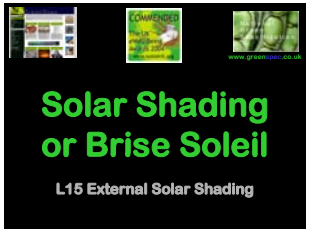


Basic Relationships: Compact LSA:FP & Solar Orientation @ HHP



Solar penetration/Capture/Shading

- Orientation of house is important but not the whole or only story
- Windows and glazed doors can be on any elevation
- Its important that any sun that reaches them can be gained
- And the building must be capable of exploiting the gains



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Shading

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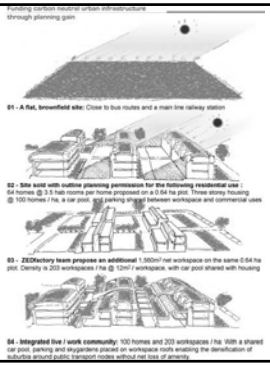
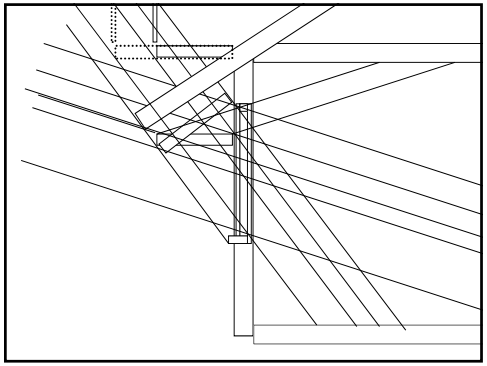
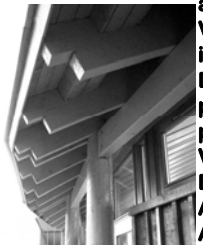
- External shading is best
- Internal shades heat up and re-radiate
- Glazing cavity louvres okay
- Balconies dual function solar shading







Layered Construction:
Simplifies details and avoids interfaces:
Ventilation zone above insulation.
Don't puncture Damp proof membrane, Gas proof membrane, Vapour barrier, Breather membrane & Air tightness layer.
Add services zones to avoid complications

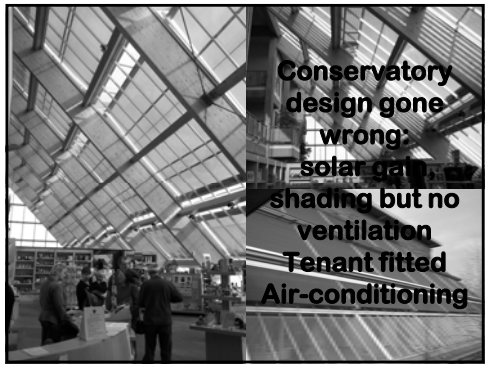
Aberystwyth Arts Centre: Architect: Smith Roberts: Peter N Roberts

Balcony offers solar protection
Closed glass balustrade offers view and wind shelter.
Open Mesh offers view and solar protection

Greenwich Millennium Village and Oxford Science Park Architect: Proctor Matthews

Open Joint Weather boarding using Rainscreen principles breaks up the pressure of the wind on the glazing behind Acts as solar shading

Earth Centre Doncaster




External Solar Shading: Roller Blinds

External Solar Shading

- Shutters, blinds, louvres, brise soleil
- Externally will reflect sun and act as shading
- Can get hot but outside the heat will be dissipated by convection, cooling wind and precipitation


Solar shading: Common in mainland Europe Will become more important in the UK if only we knew how


Internal Shutters

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- Victorians used internal shutters at night
- Shut out the cold winter wind through leaky windows to reduce heat loss (radiant heat)
- Reflect little light back in
- If used in the day time will trap warm air that can escape through leaky windows
- Painted white will reflect some heat, made of timber will not heat up and not radiate in

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Modern Internal shutters

- Internal louvres will absorb heat and then radiate inwards
- Inside the heat builds up where it is not wanted
- Dark matt colours are worse for absorption and radiation
- Silver or light gloss colours are better to reflect heat, not absorb and not radiate

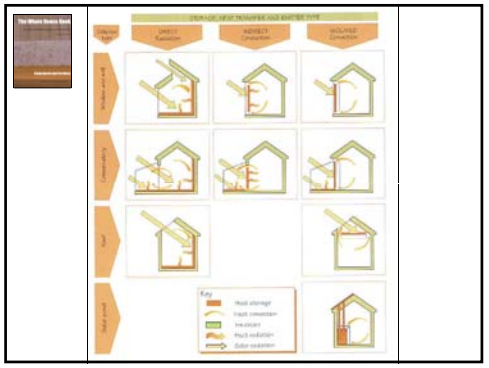

Large overhang creating covered walk

Shutters in the shade


Shutters at the windows

Overhang creates shaded balcony

Balcony overhang creates shaded verandah



Solar Orientation: Glazing or Roof?

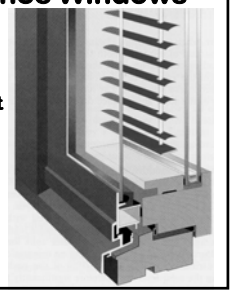
- Orientation of estate, roads, buildings and glazing to face sun: +/- 30 degrees
- Some argue this is unnecessary:
- Solar orientation the roof instead
- This presupposes that the roof will be used for Solar Thermal and Solar PhotoVoltaic panels
- EcoBling prevails over passive gains

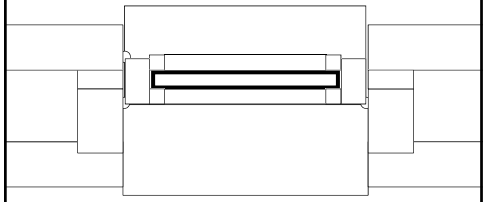
Natural Lighting

- **Daylight**
  - Windows, doors, roof windows and rooflights
  - North facing better for daylight
    - **Without the solar gains**
    - **But heat loss in winter**
    - **use very efficient windows and glazing**

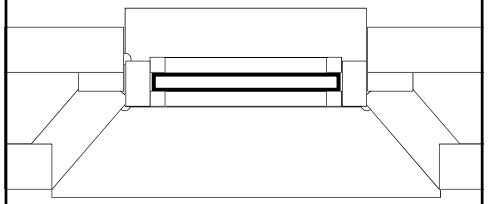
High Performance Windows

- Aluminium outer casement
- Timber inner casement
- Treble glazed
- Dust free sun blinds
- House husbands love them





Maximise light penetration Minimise glare



Natural lighting

- Avoiding electrical power for lighting of interior spaces
- Use of windows, doors, fanlights, borrowed lights, rooflights, transparent walls
- Use of open plan house and office floor layouts
- Avoidance of corridors
- Borrowed light into corridors
- Avoidance of need for sun pipes
- Use of sun pipes if all else fails

Natural lighting:

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- What about the problem of overheating with daylighting?
- Exploit north light for daylight without sunlight
- Don't natural lighting products like the Sunpipe just cost too much, at least for housing?
- Design out dark halls and corridors if you can
- Don't full spectrum lamps cost too much?
- Incandescent light bulbs will be outlawed 2011
- Use natural light

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Conservatories

- What serious role do conservatories have in minimising energy requirements?
- In the UK we have Conservatories often on the wrong side of the house with late evening occupation with central heating or Underfloor heating or electric heaters or outdoor gas heaters
- At BedZED and Hockerton they have sun spaces or winter gardens on the sunny side, which attract solar gains heat and then heat the buildings, never heated.

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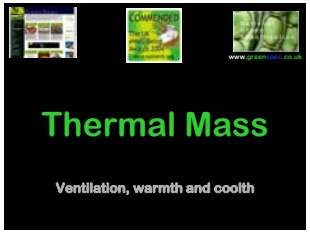

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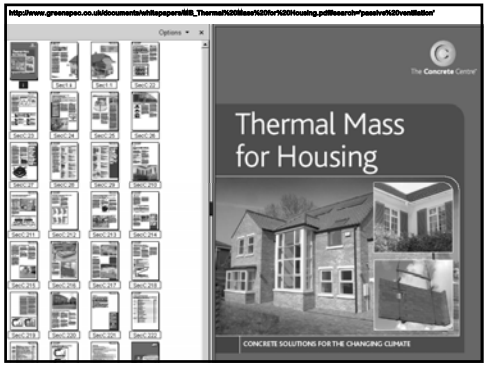
High Thermal Mass at surfaces fairfaced brick, block and plank

Heat movement in buildings

- ARUP/B Dunster Report on need for Thermal mass in buildings to cope with climate change global warming
- Recommend internal doors are self closing to hold heat energy where it is created or collected
- All partitions to be insulated
- Then actively move heat wherever you may want it or leave it where it is



Exploiting thermal mass

- If the building has high thermal mass and its surfaces are exposed
- they can be exploited in both heating and cooling
- In winter the mass can be heated in the day the heat stored for exploitation in the night
- In summer the mass can be cooled in the night and exploited in the day

Thermal mass

- Large surface areas are best
- Thickness closest to surface is used in daily cycles,
- Full thicknesses and more used over annual cycles
- Higher density material is best
- Exposed to the space not hidden above ceilings or below floors
- Exposed to the sun's rays is good
- But also at high level (hot air rises)
- Embedded pipes can be exploited to move warmth and coolth around building or into storage

Hollow core floors

- Product Reference: Termadeck
- Precast concrete plank floors with hollow cores and pathway through cores
- Connected to ventilation system
- Cooling from the inside out

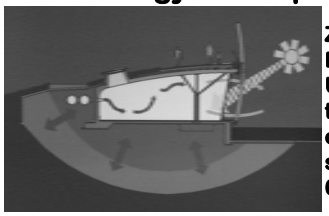
Overnight Purge Cooling

- By passively cross ventilating a building during the summer nights
- the exposed building mass can be purged the of its heat and cooled
- This allows the occupants arriving in the morning to benefit from the added coolth
- As the day warms the mass will absorb heat given off by the people and computers, etc.
- Helping keep the building lower than ambient temperature to the benefit of occupants

Inter seasonal thermal storage

- Remove collect solar energy and store it over year cycled
- Remotely in rock or salt thermal stores
- Transferred by piped liquid
- Or remove thermal insulation under and behind building and sun will heat floor and then earth below
- The heat will store for 6 months and then warm the building for 6 months

Zero Energy Development



Zero Energy Development Use of thermal mass of earth to store heat for 6 months

Mile End Road Park

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Stack effect

- Chimney stacks are a route from the building interior to exterior at high level
- With a source of heat at the base the warmed less dense air will be buoyant and rise to high level
- Cooler air will be drawn in to replace the warmed air leaving by the chimney
- Once the flow is started this effect is self propelling
- A venturi throating makes this irresistible
- This is called the stack effect and it can be exploited in designs to ventilate buildings

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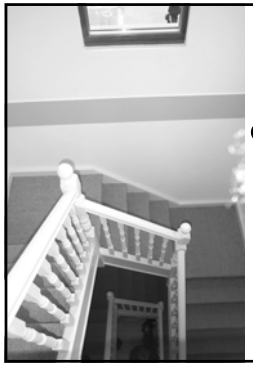
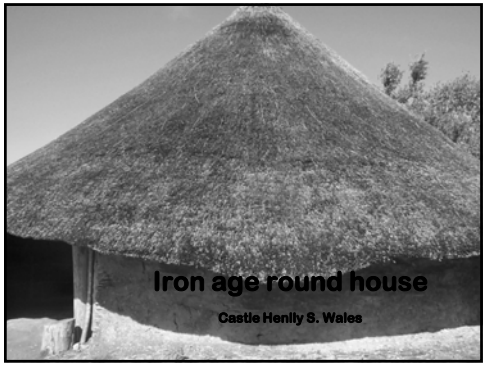


Staircase void can play its part in the stack effect
Need air in at bottom and air out at top

Roof lights, windows & vents

- High level rooflights are an essential part of passive ventilation using the stack effect without the chimney
- They need to be well insulated to minimise winter heat loss
- They are best controlled to ensure optimum performance: i.e. once a temperature is reached then open to get the stack effect off to a good start



Humidity Actuated Vents

- Passivent closed normally
- Humidity sets off vent to open and release air
- Using stack effect the humid hot air rises up the vent pipe to evacuate at high level externally
- Need a motor to extract smells
- Or unfired clay finishes to absorb them

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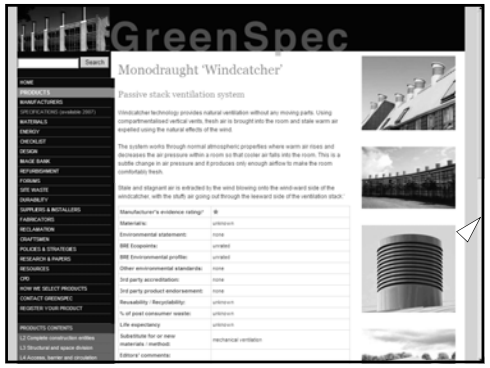
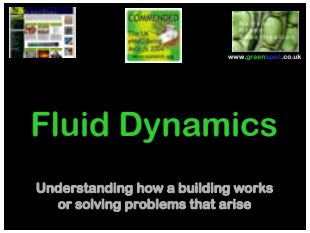
Sun Pipes & Passive Vents

- Sunpipes bring daylight and sunlight to the interior of building with no windows
- Add concentric ventilation duct
- Include valves
- But heat recovery from ventilation not normally available
- Modern substitute for the light well and chimney
- Not cheap





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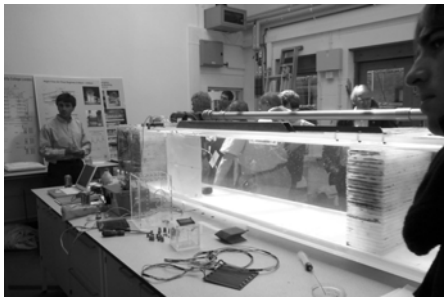

PCM Phase Change Materials

- Change from one phase to another
- Fluids change from liquid to gas & back
- Sheep's bladder water container in desert evaporates water from surface and draws heat from water
- Wax can change from solid to liquid & back
- Demands considerable energy to do so
- If the heat energy is freely available the heat can be absorbed and the change occur
- When heat is no longer available, heat released and wax reverts to solid

Computer servers

- Usually need air conditioning
- Can consider passive ventilation using stack effect to ventilate to exterior
- Can add Phase change material to absorb excessive heat
- But will it ever get a chance to cool down to dissipate the heat?
- Heat loss from other side?

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Phase Change Materials (PCM)

- This is something which CSEng's Michael Reid can talk about.)
- Wax filled panels
- Wax pellets in gypsum boards
- But not cheap

Green Walls

- Micro climates
- Natural Habitats: birds and insects
- Wind protection: heat is not blown away
- Rain protection: drying brickwork takes a lot of energy
- Solar Protection: avoids overheating
- Moisture Barrier: evaporation needs heat
- Acoustic Protection: questionable

Green Roofs

- Planning Requirement in SE London & Germany/Switzerland cities
- Cooling Function: thermal mass and moisture, plants and evaporation
- Nature: Oasis in urban areas
- DefEst: Camouflage & Heat signature disguise
- Modular tray form progressive costs
- Insurance is not an issue

Hygroscopicity

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- Hygroscopic insulation can absorb moisture and keep on insulating
- Absorbs moisture out of the air spaces into the fibres and lets the air insulate
- Evaporation also draws heat away to convert liquid to vapour: cooling effect
- Sheep's wool insulation and blankets

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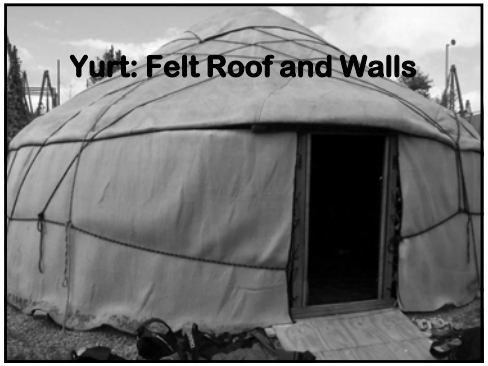

Moisture Mass

- Those in fuel poverty cannot heat their homes
- human habitation moisture in the air will condense out on cold surfaces
- Moist surfaces and ever present spores will start growing mould that can cause asthma
- Moisture absorbent materials can absorb moisture from their surfaces
- Spores in the air can land on those dry surfaces and not start growing
- Unfired clay brick/block, clay plaster or clay finish

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LCGB: Low Carbon Green Buildings

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