Technological Innovation In Sustainable Design philosophy and practice

GBE LSBU 2016/17
RIBA Part 2 Year 2 EREID

- **so called low and intermediate technologies**
- https://en.wikipedia.org/wiki/Low_technology
- https://en.wikipedia.org/wiki/Appropriate_technology
- https://www.britannica.com/technology/intermediate-technology

Technological Innovation In Sustainable Design philosophy and practice

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Extra Lectures

History of Building

- Historic methods of construction have responded to the materials that were readily available locally
  - Sometimes if the client is the church, rich, powerful, respected: from further afield
- Local stone, local trees, local earth, Cob
- Through a process of trial and error
- Techniques and materials were discovered, repeated, improved and refined
  - Lime mortar, lime plaster, horse hair, horse manure, straw thatch, turf roof, hedge bank walls
  - Lime paint, mineral dyes, insect dyes, egg, milk
- SPAB, STBA

Traditional Techniques

- Are those that have been successful over many repetitions
- Work for the climate and required internal conditions
- They have been adopted and skills developed around them
  - Livelihoods build around them, reputations gained,
  - Skills passed down father to son, master craftsmen to apprentice, and survived
  - Craft based, Artisan, Labour intensive
-

Master Builders

- Today's Architect (minus building skills)
- Significantly more wide ranging and appropriate knowledge and skills than today
- Designed and worked with the artisan craftsmen tradesmen to get stuff built
- Durable materials, natural materials, slow techniques, labour intensive
  - Ropes, block and tackle,
  - needing skilled and knowledgeable craftsmen
- Created Cathedrals that last forever
  - (with repairs and maintenance)
- **City Castle Cathedral Illustrated book**

Master builders no longer

- Over the centuries buildings got more sophisticated
- Needed to be more complex, bigger, wider or taller
- Needed to go beyond the limits of local and traditional materials and methods
- Moving from Trial and Error,
  - to Rule of thumb
  - towards Calculations and modeling
-

General Contractors

- With tradesmen employees
- Full responsibility for the whole job
- Joined up responsibility
- Joined up thinking
- Skills and Care

1850 Industrial Revolution

- Coal Combustion Engines
  - Mechanisation
  - Mass production
- Global distribution
  - To and from Commonwealth
  - British Empire
- Global sourcing
  - (uncontrolled abuses of everyone and everything)

Growing populations and mobile workforce

- Building needed to be built faster
  - Still labour intensive
  - Progressively labour becomes expensive compared to materials
    - Need to develop faster techniques and faster materials
- Cheaper, faster
-

Historic > 1919 > Modern (UK)

- Solid wall construction moisture vapour and water permeable
  - Ventilated by air leaky sliding sash windows and air bricks
  - Lime mortar flexible mass masonry
- Cavity wall construction separation and damp proofing
  - No insulation requirement yet
  - Ventilated cavity
  - Cement Mortar rigid thin masonry
-

1950's Oil Production

- By-product of oil refining
  - Hydro-carbon plastics
- High oil consumption
  - High by-product production
  - Needs high by-product consumption
- Design education:
  - All about short life products
  - Disposable consumer goods
- 'Story of Stuff' (Video)
-

1950's Treaty of Rome

- The beginning of European Law
- Case law "Or Similar"
-

1962 Cuban Missile Crisis

- Campaign for Nuclear Disarmament
- Bomb shelters at city and family levels
- Autonomy (from mains services)
  - **Water supply**
  - **Sewerage**
  - **Power**
  - **Communications**
- **Food not so easy underground**
  - **Bottled, canned and dried**

1960's Insulation requirements started

- 1962 Building Regulations replace bylaws (Except London)
  - U values start to be required (Except London 1980's)
- Inner leaf of cavity masonry
  - Brick > Block
  - Breeze block (Air permeable)
  - Concrete Block (Dense aggregate)
  - Later AAC (autoclaved aerated)
-

1960's Housing programme

- Call for Fast Construction Methods
- Clear felling whole communities
- Sky and ground scrapers in their place
- Precast concrete sector responded
- Uninsulated (or inadequately insulated)
  - Thermal bridges at edges > Condensation > Mould or corrosion
- Unskilled labour force
- Rushed construction
- Poor jointing of panels, condensation corrosion and catastrophic failures

1960's Environmental consciousness

- Remote wars
  - environmental and human damaging
  - radioactivity and chemicals
- Student battles with establishment
  - Civil Disobedience (done effectively)
- Anti-apartite
- Greenpeace against
  - nuclear bomb testing in the ocean
  - nuclear power,
  - whaling,
  - anti-PVC
-

1968 Apollo 8

- **Moon circumnavigation**
  - Apollo 8
- First time an astronaut looked back at the earth
- Saw it as a spacecraft carrying billions of humans
- We need to be autonomous on our only planet, long term
-

1970's Oil Crisis

- 2 price rises for oil by OPEC
  - Protect the oil reserves
  - Stop us squandering energy
- China asked everybody to do everything possible to reduce demand
- Australia insulated its houses
- UK and USA complained again about the 2nd price increase
- China and Aus. "Crisis? What Crisis?"

1980's Passive Design

- Enthusiasm for low energy demand houses across EU and World
  - Solar gain
  - Thermal mass
  - Trombe walls
  - Solar trap glass houses
- UK Energy World at Milton Keynes
  - Demonstrations of energy efficiency
  - Passive design
- A passing phase
  - (gas discovered in the N Sea)
  - Back to business as usual

New materials and new methods

- Less natural and more chemical
- More synthetic and petro-chemical
- More inventive and innovative
  - CFCs in blowing agents in plastics for greater thermal resistivity
  - Less healthy
  - (in many cases not knowingly so, but not always)
- Less sympathetic to existing context:
  - local materials, local trades
- Manufacturer focus on cheap method of mass production
- Many are worse for humans, nature and environment
- Violet materials

Subdivision of training and professions into silos

- Needed more professions to subdivide the design skills and develop them in more complex ways
  - Constructor, Tradesmen
  - Architect, Technicians, Structural Engineer, Services Engineers, Acoustic Engineers, Civil Engineers
  - Quantity Surveyors
  - Interior Designers, Furniture Designers, Signage Consultants
  - Façade Consultants, Cleaning Consultants, Risk Assessors
  - Later Environmental Assessors
- Risk that nobody has the knowledge anymore rely on specialists
- Silo mentality
  - Nobody likes anybody else
  - But everybody hates the Architect

Quantity v Quality

- Quantity Surveyors
  - care about the cost of everything
  - and the value of nothing
- Building Price Books
  - CAPEX Capital Expenditure
  - No interest in OPEX Operational Expenditure
  - Violet Construction Violet prices
- With Encouragement and Fiduciary Rules
  - Client use QS to control costs
  - QS only understand Cost Cutting
  - Later: Value Engineering posh for cost cutting

Contractors replace Constructors

- Biggest contractors
- Run by Quantity Surveyors
- Bean counters and cost controllers
- Less interested in building quality?
- Substitute quality with inferior products N#778

Procurement Methods proliferate

- Clients want or are encouraged to demand faster programs
- Different procurement methods experimented with
  - to overlap design time with construction time
  - D&B Design and Build
  - MC Management Contracting
  - CM Construction Management
  - DMC Design Manage Construct
- Permutation just to be different
  - GMP Guaranteed Maximum Price

Passing on responsibility?

- Only with clients explicit permission
- D&B Design and Build
  - (D&B&R Design and Build and Redesign)
- A Brief not a Specification
  - Employers Requirements
- Contractors and Constructors are not designers
  - But now they are expected to have the skills
- Fiduciary Rules take over
  - Substitution and Surreptitious Substitution
  - Specification quality not controlled by Architect anymore
  - Novation messes that up

Prescriptive > Performance Specification

- Prescriptive:
  - use these materials in this way
- Performance:
  - Wall must perform to these standards
  - Make the wall out of what you want

Subdivision of responsibility

- Contractors have not got the skills of Constructors
- Nor do they have the continuity of responsibility, less joined up thinking
- New Skills:
  - Employers Agent, Project manager, Risk assessors, Package manager, Design managers
- New Skills developed:
  - Cover Your Arse letter writing,
  - Claims making
- Skills training but no time to care

Preoccupation with thinness

- The industry remains preoccupied by thinness of construction
- Building owners and developers
  - To minimize thickness of walls
  - To maximize floor areas
  - To charge more for buildings
- Results in encouraging manufacturers of plastic insulation
  - to use ozone destroying CFC
  - Later replace with HCFC, HFC, HFA
  - To keep ahead of legislation

1980's Environmental consciousness reaches construction

- Convention On International Trade In Endangered Species Of Wild Fauna And Flora, (CITES)
  - Tree species to be avoided in construction (ignored by many)
- Red List
- IUCN List
- FoE Friends of the Earth: Good Wood Guide
  - Discouraged use of endangered species trees
  - Encourage Equivalent Performance Species timber
- WWF World Wide Fund for Nature
- Global warming down to man made Carbon Dioxide
- Ozone layer destruction by chemicals
  - Needs to exclude them from insulation, refrigeration and fire fighting installations
- 'Global Warming' replaced by 'Climate Change'
- Urban Heat Island Effect (UHIE)
  - Don't make more heat than you need
  - Don't pump air conditioning heat to the atmosphere

Consumer/Specifier choices

- FairTrade
- Rug mark
- FSC Forest Stewardship Council
  - Challenged by PEFC as too onerous
  - Lobbied and UK Gov. downgraded FSC to = PEFC
  - EUTR Legal and Sustainable
- ETI Ethical Trading Initiative
  - Fair stone Paving (Private scheme)
- ISO 26000 (Social Responsibility)
- Low VOC paints
  - (until they all have to comply in 2012)

1992 EU Standards Prevail

- Construction Product Directive (EU)
  - Construction Product Regulations (UK)
  - No technical barriers
  - Building Regulations: Regulation 7
  - CEN: EN & EC replace BSI: BS and CP
- Proper Materials
  - BSI Kitemark, BBA Certificate,
  - ETA European Technical Approval
- Essential Requirements
  - CE Mark
    - (minimum legal requirement to sell in EU)
    - Maximum permitted to specify in public procurement
  - Later add LCA (basis for green claims)
- Or Equivalent replaces Or Similar
- Later: Green Public Procurement

Substitution: Or Equivalent

- Public Procurement
  - No Technical barriers permitted
  - Must permit 'Or Equivalent'
  - Not permitted to require more than CE mark (legal minimum)
- EU banned Reverse Engineering
  - Copying an industry standard (eg. IBM PCs)
  - Every company copied and exceeded std.
  - But no evidence of policing

Health and Safety reaction to fails I

- Health & Safety at work
- Controlled Waste Regulations
  - After deaths at landfill sites
- CHIP transporting hazardous materials
  - Tanker discharges at landfill
  - Tanker accidents/fires on the road
  - FR Identification of content on vehicle
- CDM Construction Design & Management Regulations
  - Less hazardous construction and maintenance of buildings
  - Architects design responsibility is growing

Health and Safety reaction to fails II

- Environmental Protection Acts 1990s
  - Duty of Care
- ODS Ozone Depleting Substances
  - Long and slow (still ongoing) process of stopping production
  - Blending gasses to keep it going longer
  - Excluded from developed countries
  - Permitted in developing countries
  - Becomes a second problem at demolition stage

Health and Safety reaction to fails III

- COSHH Control of Substances Hazardous to Health
  - Materials Safety Data Sheets (MSDS)
  - Often incomplete
- Hazardous Waste Regulations
  - 240 materials reclassified
  - Hazardous landfill sites reduced from 240 to 10
  - Requires 'treatment' before landfill
- REACH Registration Evaluation and Authorisation of Chemicals
  - Because MSDS not always complete
  - Reconsider recipes and ingredients
  - Substitute It Now List (SIN)
  - Substances of Very High Concern (SVHC)

Financing methods

- Government decided they did not want to maintain an estate of building
  - It wanted to provide Public services in buildings maintained by others
- PPP Public Private Partnerships
  - **Shared expenses and profits**
- PFI Private Finance Initiative
  - **Upfront Expenses (£1m bid)**
  - **With rear end rewards (charge what you like for services)**
  - **10 x the true costs for alterations**
- **BOOT Build Own Operate Transfer**
  - **25 year contract servicing the buildings**
  - **25 year warranties for short life materials**
  - **Pay insurance premiums for life**
  - **Instead of paying for durable materials**
- Contractors gave up construction to be Facilities Management
  - **Some did both**

Growing housing crisis

- Developers will not build unless they can make 30% profit
- Deliver slowly to keep market hungry
- To ensure high sales price
- But failing to close the 'performance gap'
- ZCH project to get competent buildings to help meet UK Carbon targets

Innovative Methods of Construction IMC

- IMC is a term that covers a range of technologies and types of prefabrication and/or off-site assembly - it is also referred to as MMC,
  - Off-site Manufacturing (OSM),
  - Off-site Production,
  - Off-site Fabrication,
  - Modular Construction,
  - Pre-fabrication,
  - Pre-assembly,
  - Standardisation.
- The two basic forms of off-site manufacture are:
  - volumetric construction, in which complete, fitted units like kitchens and bathrooms are prefabricated and transported to site in the form of 'pods'.
  - panellised construction, where elements like walls and floors are transported in flat packs and assembled.

Modern Methods of Construction MMC

- Though to be the solution to housing crisis
- Mass Factory Production
  - Off-site Prefabrication: Modules, Pods, Panels
    - Some (less waste in factory)
  - On site assembly
    - Little waste on site
- Fears of repeats to 1960's sky and ground scraper problems
  - Not normally concrete this time
  - Panel and jointing issues:
    - Coordination Tolerance Accuracy
    - Air and Wind tightness
    - Thermal break
- Thin panel construction
  - Wrong insulation and overheating potential

BRE Green Guide to Specification (GGtS) (Book)

- Uses Life Cycle Analysis (LCA) to rank methods of construction
  - 1200 > 1500 elemental assemblies included
- Greenwich Millennium Village
  - more applied to proposals (therefore in the bin)
- Based on environmental Impacts
  - lots of theory and number crunching (expensive)
- ABC banding A being lowest impacts
  - ABC needed to be rebadged DEF and ABC were missing
  - The least violet of the violet methods of construction
  - PVC windows A rated (but none better than C)
- Not Green and not about specification
  - Biased towards Business as Usual materials
- Industry sector data and averaging at every step
  - Generic materials Ratings
  - Company can hide behind sector averages or sector ratings
  - No incentive to improve
- Effective barrier to green construction materials and methods
- Specfiers adopt it for the easy answer to violet choices
- Green specifiers in the know do not trust it

Green/Healthy/Social labels

- Are always about one manufacturer and one product
  - (not sector averages)
- Usually limited to one issue (not always)
- Natureplus (German)
  - Competent
  - Healthy
  - LCA
- Highlights the best in class
  - (Natureplus only the top 10% could achieve pass levels)
- Incentive to improve
- Specifiers choose product for their properties

Recycled Content Building Products and Materials

- Driven by landfill legislation changes
  - Landfill gate charges
  - Aggregate Levy on virgin aggregate encouraging recycled
  - Landfill taxes
  - Escalating price differential between inert and hazardous waste
  - Landfill capacity shrinking fast
- WRAP drove program to reduce waste and divert waste from landfill
  - Primarily focused on recycling in preference to reclaim and reuse
  - Adding synthetic adhesives to bind recyclate to make new products
  - More unhealthy materials in the market place
  - Inadvertently shrank the architectural salvage and construction reclaim and reuse sectors

Improving Airtightness and Energy performance

- Slowly increasing requirements for improved U values and reduced air leakage
  - Requires competent vapour checks and Breather membranes in vapour-closed construction or
  - Requires competent vapour permeable, air and wind tightness membranes in vapour-open construction
- Improved airtightness lead to Indoor Air Quality (IAQ) issues
  - caused by off-gassing of materials and adhesives
  - making building unhealthy places to be
- Solutions include using:
  - hygroscopic plant based insulation in vapour-open construction
  - Plant- and tree-based (low solvent, no chemical) materials
  - Mineral based paints with mineral pigments

Overheating

- ZCH Zero Carbon Hub
  - never really understood overheating after 10 years of research and publications
- Building Regulation drives thermal conductivity and resistance
  - Good to keep winter and summer heat in
- Decrement delay ignored by regulations:
  - time for solar radiant heat to pass through materials
  - Good to keep summer heat out
- Dense wood fibre, cork, cellulose fibre, cellular glass now available in the market
- Particularly important in thin-walled plastic-insulated MMC and IMC construction

Low & Sequestered Carbon Materials

- Timber sector large disjointed
  - took decades to join together in common thread marketing
  - Finally have low carbon and sequestered carbon as good stories for all to tell
- Off the back of LCA
  - embodied and sequestered carbon datasets are building
  - And tools, ICE databse
  - Embodied and sequestered carbon calculators enable accurate claims to be made
  - T&CP Precedents have been made to compete with RE obligation % (Merton Rule)
- Solid Wood Solutions (SWS)
  - very prevalent in EU become popular in UK
  - Cross laminated timber panels (CTLP) are popular
  - Kier Construction Substitute it into projects for speed of construction
- Adhesives in CLTP are not healthy
  - Stacked plank and doweled (brettstapel) offers glue-free healthy solutions

Mineral Materials

- The industry remains preoccupied by thinness of construction
  - forcing plastics to destroy ozone.
- Silica in solution minus water makes Aerogel
  - conduction thermal insulation developed by NASA
  - **Used to minimize the effect of thermal bridges at door and window openings**
  - **High performance (only beaten by VIPs)**
- Aluminium sheathed mineral balls evacuated air
  - to make Vacuum Insulated Panels (VIP)
  - **Best conductivity performance**
  - **but useless against solar radiation heat**
- 65% lower carbon blended cement for concrete
- Carbon sequestered manufactured aggregate for concrete

Health and Wellbeing

- Increasing airtightness, poor materials choices and deteriorating indoor air quality
  - Ill health due to IAQ and numerous wellbeing issues drive change
  - Health and Wellbeing standards appearing in
    - Ska for Higher Education
    - WELL (USA)
    - BREEAM soon
    - Building Biology Association course
- Low VOC paints driven by 2012 legislation
- Lower VOC timber panel products and adhesives appearing in the market

Newer (1 - 2 decades) to the UK constructional systems

- ISPS Insulated Structural Panel Systems
- SIPS Structural Insulation Panel Systems
- Extruded Fired Clay
- Hemp-Lime
- CLTP Cross Laminated Timber Panel Systems
- SWS Solid Wood Systems
- See LSBU Part 1 Year 1 seminar series for elemental construction methods

Newer (1 - 2 decades) materials to UK construction

- Cellulose Fibre Flake
- Dense Wood Fibre
- Cork insulation
- Cellular Glass
- Clay
- Unfired clay
- Aerogel
- Vacuum Insulated panels
- http://greenbuildingencyclopaedia.uk/uncategorized/materials/

Graphene at Microscopic level

- Carbon at microscopic level microscopic additions to recipes
- Amazing properties of
  - strength, toughness, durability and thinness
- Has potential to revolutionize most materials and most sectors
- **Innovative materials probably has many applications, yet to find out**
- It is taking time to work out how

Graphene Revolution on the horizon

- Product are starting to arrive
- Lime paints with grapheme added to recipe
- Many great properties
- Many Green Labels
- USB stick with literature
  - and virus file on board

CAD

- Is not new and you all have access to it
- Software and Apps are developing fast
- That allow us to design and make things without artisans
- The challenge will be to join components together in an intelligent and competent way

CADCAM is not new tech

- Computer Aided Design Computer Aided Manufacture
  - Its having a growth spurt in the design world
- Recent Developments are accessible to many of us and have the potential to make a big difference
- Many technologies are becoming more accessible to designers than ever before
  - I can CAD, CAD can, So I do
- The Great Recovery project
  - local innovation centres making prototypes is easy
- Interreg project:
  - 'Makers, Fixers and Hackers'
- Furniture design
  - No craft skills needed
  - resource efficient design
  - cutting parts from single sheets with minimal waste
- Buildings can be made like this
  - Wiki House

3D Printing +ve techniques

- Lazar light rays in 3 plains project into liquid
  - at point of light crossing the liquid solidifies
- Scanning planned to work from bottom and middle
  - working outwards and upwards until whole design complete
- Liquid drained off away until the object revealed
- Conran's son had WCs prototyped in this way
-

3D Printing +ve techniques

- Printing with dry powder in a thin layer over an area
  - then scan by lazar light to fuse the powder in the layer in specific places,
  - working like photocopiers;
  - repeat layer upon layer with a different design in each layer until an object is created within the block of powder.
- Like archeology the powder brushed away until the object revealed.
-

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3D Printing

- Machine head driven by computer
- Scanning following pattern in computer model
- Depositing material (endless supply)
  - Plastic strip (unhealthy off gassing)
    - Bio-plastic (healthier) PLA PolyLactic Acid
  - Metal (made molten at delivery head)
  - Concrete (un reinforced)
  - Clay > Ceramic

CNC 3D Milling –ve techniques

- Usually of flat surface
  - timber based board, metals, plastics
- CNC Milling heads driven by CADCAM computer
- Most interesting when cutting through surfaces with multiple layers of contrasting colour
- Cut part way through to contrasting colour
  - make signs with contrasting coloured letter in plain sheet
- Cut landscape model where contours shown by contrasting layers

Laser Cutting

- Usually of flat sheet
- timber based board, metal, plastics
- **Any pattern you like**
  - **but must maintain integrity**
  - **Hold itself together**
- **The challenge is to be resource efficient and waste close to nothing**
  - **Iteration software to optimize layout of components**

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Water Jet cutting

- Fine water jet (not too destructive)
- High Pressure (cut through materials)
- Stone
  - Cut through
  - Surface relief
- Contrasting layers: Mix and match
  - +ve and –ve contrasting pairs
  - Used at Bluewater Shopping & Leisure
    - Mall floors
    - Leaf patterns
    - River Thames cut in stone floor

New engineering services systems

- Hydro electric power
- Wave power
- Wind Power
- Rain Water harvesting (RWH) for reuse
- RWH with Water Source Heat Recovery
- Solar Thermal (ST)
- Photo Voltaic (PV)
- Photo Voltaic Thermal (PVT)
- Passive Ventilation
- Passive Ventilation with Heat Recovery (PVHR)
- Mechanical Ventilation with Heat Recovery (MVHR)
- Heat Pumps (HP)
- Ground Source Heat Pumps (GSHP) or coolth
- Air Source Heat Pump (ASHP)
- Water Source Heat Pump (WSHP)
- Geo thermal heating (GT)
- Air source Condensing Heat recovery (night and day)

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Feedback

- These files are created by generalists with a big dollop of green flavour
- These files are updated from time to time
- We are not experts so from time to time these file may get out of date or may be wrong.
- If you feel that we have got it wrong please let us know so we can put it right

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