Tech Lecture 01
Building Envelope Principles

Advanced Technology Module Code: 5CTA1140
Semester A: Weeks 10 -25
Credits: 15
Course Leader: Ilona Hay
Module Coordinator: Brian Murphy
Lecture Author: Kenny + Brian Murphy
Lecturer: Brian Murphy
Lecture 01: Week 10 3:30-4:30pm
8th October 2019

Is this Architecture or Sculpture or is it Both?
It is a façade and it might be a roof
It has no windows in the façade just urban sized glazing
He uses expensive cladding materials most of us cannot afford
Titanium etc.

"Architecture should speak of its time and place, but yearn for timelessness."

Frank Gehry, Architect

Week	Tuesday	Lecture	Arch/IDA Tech	Lecturer Time	Arch Design
Wk 9	24/09/19	Void	Induction	Induction	Induction - no class
Wk 10	01/10/19	Void	Void	Void	Arch Design 1 launch Site Visit
Wk 11	08/10/19	Lecture 01	Module Introduction Tech Task 1 Touch/Stone Launch Adopt a Material Fixings Fasteners Workshop Introduction Tutors: Brian Sonia Alex	Building Envelop Principles/ Lecturer: Brian 3:30-4:30pm	Arch Design 1 Group Table top Site studies Tutorials - Work in studios
Wk 12	15/10/19	Lecture 02	Studio Tech Task 1 Adopt a Material Tech Tutor: Sonia	Introduction to Materials/ Adopt a Material Lecturer: Sonia Tong 3:30-4:30pm	Design 1 work in studio
Wk 13	22/10/19	Lecture 03	Studio Tech Task 1 Adopt a Material Tech Tutor: Alex	Sustainability Principles Lecturer: Alex Veal 2:00-3:00pm	Design 1 work in studio
Wk 14	29/10/19	Lecture 04	Tech Task 1 Submit Adopt a Material Tutors: Brian Sonia Alex	External Walls, Roof & Openings Doors Windows Lecturer: Brian 3:30-4:30pm	Design 1 Crit + Review with Client
Wk 15	05/11/19	Void	Void	Void	Arch Design 1 (Reflection) Submit Arch Design 2 launch Self assessment/updates
Wk 16	12/11/19		Tech Task 1 (Reflection) Submit	Independent study week No Lectures	Design 2 work off site
Wk 17	19/11/19	Lecture 05	Arch Tech 2 launch Material Application Tech Tutor: Sonia	Floors ceilings partitions Lecturer: Sonia 3:30-4:30pm	Design 2 work in studio
Wk 18	26/11/19	Lecture 06	Studio Tech Task 2 Material Application Tech Tutor: Brian	Passive Performance Noise Light Heat Vent Cool Services Response Lecturer: Brian 3:30-4:30pm	Design 2 work in studio
Wk 19	03/12/19	Lecture 07	Studio Tech Task 2 Material Application Tech Tutor: Alex	Building Structures /Furniture Strength & Stability Lecturer: Alex Veal 2:00-3:00pm	Design 2 work in studio
Wk 20	10/12/19	Lecture 08	Tech Task 2 Submit Material Application Tutors: Brian Sonia Alex	Existing Building Survey/ Historic Fabric Performance Lecturer: Sonia 3:30-4:30pm	Design 2 work in studio
Wk 21	17/12/19	Void	Tech Task 2 (Reflection) Submit	Void	Arch Design 1+ 2 Crits with Guest + Self Assessment
Wk 22	24/12/19				Design 2 reflection
Wk 23	31/12/19				
Wk 24	07/01/20				
Wk 25	14/01/20	Lecture 09	Tech Task 3 launch Room Tech Tutor: Brian	Future Systems Sustainability Lecturer: Brian 3:30-4:30pm	Arch Design 2 (Reflection) Submit

Today's Lecture

Building Envelope Principles

1. First Principles
2. Components & Checklist
3. Design Considerations
4. Performance Requirements
5. Lecture Summary

First Principles
What are buildings for?
What is their purpose?

First Principles
What are buildings for?
What is their purpose?

1. Shelter
2. Comfort
3. Security & Purpose

A simple wall can become;
- an object to lean against
- a place to enjoy the sun during the day
- protection from the elements; wind, sun, rain but not necessarily all at the same time
- thermal mass (Stones) if warmed by the sun will reradiate heat at night
- A cloudless night will suck the heat away

First Principles

1. Shelter
- basic shelter from the weather
- separation from damp earth
- basic storage (food & water)

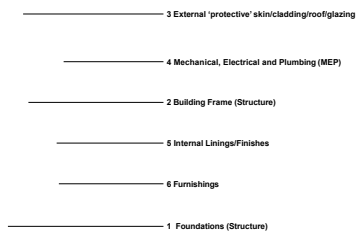
2. Comfort
- enhanced shelter from weather
- warmth and cooking
- simple furnishings

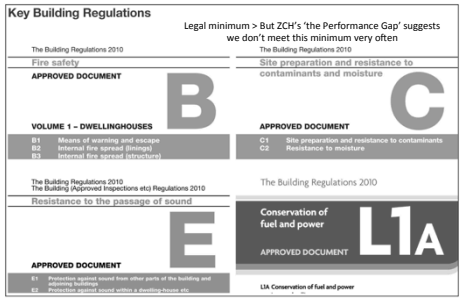
3. Security & Purpose
- full protection from weather
- a 'home' for activities
- security/ safety

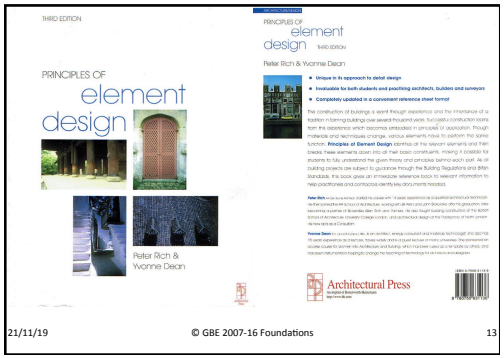
Components

Banham Group Headquarters, Thornsett Road, London
Allies and Morrison

Typical Building Checklist







Floor Actions

Gravity: downward pull
Wind: Motive force (suction), pressure buffeting, Destructive, Penetrative
Rain: Moisture deposition, penetration
Snow: Moisture deposition, loading, slush carried in, material degradation
Moisture vapour: permeation, condensation, insulation impaired
Sun: Temp variation, thermal movement, heat gains, Chemical decomposition
Dirt and Dust: infiltration, deposition, surface pollution, surface erosion
Chemicals: surface corrosion, disintegration, decomposition
Sound: Noise nuisance, impact, rattle, creaking,
Attack: Manual, Ballistics, Bomb Blast
Thermal: heat loss, cold to touch, radiant coolth, condensation,
Deposits: chewing gum, staining, adhesion, trip hazard, surface texture penetration
Gases: Ground gases: Radon (Radio Active), Methane
Moisture: flood water, ground water rising, capillary attraction, moisture transfer

Floor Reactions

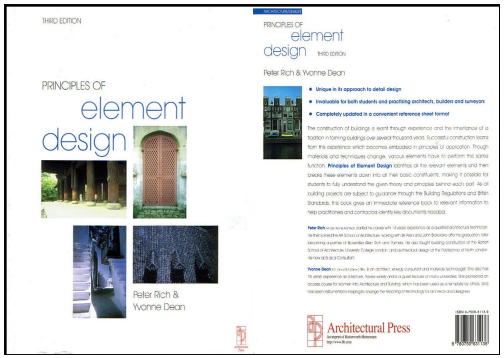
Gravity: Support
Wind: rigidity, resilience, sealing, air tightness layers and detailing
Rain: deflection, impervious skin, absorption and drainage, sealing
Snow: deflection, impervious skin, absorption and drainage, sealing
Moisture vapour: resistance, hygroscopicity, permeability, breathing, moisture mass
Sun: movement joints, insulation, shielding, invulnerable materials
Dirt and Dust: repulsion, exclusion, shielding, cleaning
Chemicals: invulnerable materials, exclusion,
Sound: Insulation, absorption, acoustic mass, separation, isolation,
Attack: toughness, lamination, edge restraint, edge protection
Insulating: thermal insulation, thermal mass, U value, G value, cold bridge avoidance/minimisation
Deposits: smooth impervious surface, flush impervious joints,
Gases: Gas/Damp proof membrane linked to G/DPC
Moisture: Elevation of floor above flood plain, Separation, water resistant materials, Damp proof membranes linked to DPC

Principles of Element Design: Floors

- Appearance
  - Interior and exterior materials and finishes
- Structural strength and stability
  - Load-bearing
  - Wind resistance
- Weather barrier
  - Rain, snow, wind, sun, dirt dust pollution
- Durability
  - Moisture resistance, frost, mould
  - Moisture Mass & Hygroscopicity
  - Ozone and sunlight degradation
- Thermal Performance
  - Heat Resistance: loss and gain
  - Condensation Avoidance
  - Airtightness
  - Avoidance of Cold Bridges
  - Thermal Mass
- Movement
  - Structural , thermal, moisture, Frost heave
  - Chemical

Principles of Element Design: Floors

- Acoustic Performance
  - Resistance, absorption
- Fire Performance
  - Surface spread of flame
  - Fire Resistance
- Security
- Inspection and maintenance
  - Inside & out
- Pest infestation
  - Termites,
  - Termite Barriers
- Rising damp
  - Barriers
  - Capillary Attraction
  - Hygroscopic or Hydrophobic
  - Frost action
- Health
  - Moisture Mass
  - Low allergy materials



Wall Actions

Gravity: downward pull
Wind: Motive, Destructive, Penetrative
Rain: Moisture deposition, penetration
Snow: Moisture deposition, loading
Moisture vapour: permeation, surface and interstitial condensation, insulation impaired, material degradation
Sun: Temp variation, thermal movement, solar heat gains, Chemical decomposition
Dirt and Dust: infiltration, deposition, surface pollution
Chemicals: corrosion, disintegration, decomposition
Sound: Noise nuisance, from within and from without
Attack: Manual, Ballistics, Bomb Blast
Thermal: heat loss, radiant coolth, condensation, stack effect

Wall Reactions

Gravity: Support & restraint
Wind: rigidity, resilience, sealing, air tightness layers and detailing
Rain: deflection, impervious skin, absorption and drainage, sealing
Moisture vapour: resistance, hygro-scopicity, permeability, 'breathing', moisture mass
Snow: deflection, impervious skin, absorption and drainage, sealing
Sun: movement joints, insulation, shielding, invulnerable materials, decrement delay
Dirt and Dust: repulsion, exclusion, shielding, cleaning, covering
Chemicals: invulnerable materials, exclusion,
Sound: Insulation, absorption, acoustic mass, separation, isolation,
Attack: toughness, lamination, edge restraint, edge protection
Insulating: thermal insulation, k and U value, thermal mass, thermal bridge avoidance/minimisation,
Glass: G value,

Principles of Element Design

Appearance
- Interior and exterior materials and finishes

Structural strength and stability
- Load-bearing
- Wind resistance

Weather barrier
- Rain, snow, wind, sun, dirt dust pollution

Durability
- Moisture resistance, frost, mould
- Moisture Mass & Hygroscopicity
- Ozone and sunlight degradation

Thermal Performance
- Heat Resistance: loss and gain
- Condensation Avoidance
- Airtightness
- Avoidance of Cold Bridges
- Thermal Mass

Movement
- Structural , thermal, moisture, Frost
- Chemical

Principles of Element Design

Acoustic Performance
- Resistance, absorption

Fire Performance
- Surface spread of flame
- Fire Resistance

Security

Inspection and maintenance
- Inside & out

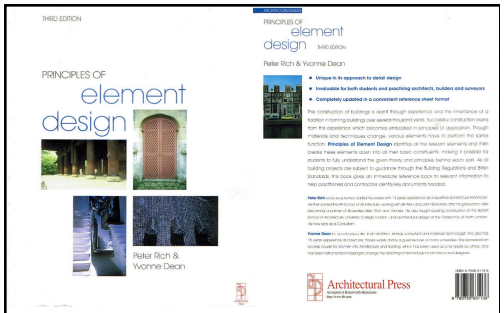
Pest infestation
- Termites,
- Termite Barriers

Rising damp
- Barriers
- Capillary Attraction,
- Moisture Transport
- Hygroscopic or
- Hydrophobic
- Frost action

Health
- Moisture Mass
- Low allergy materials

Weather Envelope

Absorbent – Repellent – Open Joint Panelled
Masonry – Curtain Wall – Rainscreen
Thatch



Flat Roof Actions

Gravity: downward pull
Wind: Motive, Destructive, Penetrative, Scour, concentration of ballast and blow off roof
Rain: Moisture deposition, penetration
Snow: Moisture deposition, loading
Sun: Temp variation, thermal movement, solar radiation heat gains, Chemical decomposition
Dirt and Dust: infiltration, deposition, surface pollution
Chemicals: corrosion, disintegration, decomposition
Sound: Noise nuisance, from within and from without flanking from adjacent

Flat Roof Reactions

Gravity: Support & restraint
Wind: rigidity, resilience, sealing, wind and air tightness, bonding/ fastening/ballast, high upstands
Rain: deflection, impervious skin, absorption and drainage, sealing
Snow: retention, deflection, impervious skin, absorption and drainage, sealing
Sun: reflection, albedo, thermal mass, decrement delay, movement joints, radiation, convection and conduction insulation, shielding, invulnerable materials
Dirt and Dust: repulsion, exclusion, shielding, collection, cleaning, demineralisation
Chemicals: invulnerable materials, exclusion, bio-remediation
Sound: Insulation

Principles of Flat Roof Design

- **Roof form and types of weatherproof coverings**
- **Structural strength and stability**
  - +ve and –ve pressure
- **Weather shield**
- **Rain and other precipitation**
- **Snow: Weight, insulation, reflection, Slippage, melt water run off**
- **Wind**
  - Wind driven rain, wind driven snow, wind scour of ballast, wind driven melt water,
- **Sun**
  - UV radiation
  - Solar radiant Heat resistance
  - Internal conduction insulation
  - Overheating
- **Dirt and dust**
- **Thermal performance**
  - Thermal movement
  - Heat Gain and resistance
  - Heat loss and retention
  - Condensation risk
- **Drainage:**
  - –
  - –
  - –
- **Durability**
- **Sound insulation**
- **Maintenance**
  - –
- **Security**
  - –
- **Fire,**
  - –
  - –
- **Roof Access: Maintenance, cleaning, inspection, Safety**
- **Ventilation**
- **Rooflights**
  - –
- **Insect exclusion or selective inclusion**
- **Bat and Bird exclusion or inclusion**

Principles of Element Design

Appearance
- Interior and exterior materials and finishes

Structural strength and stability
- Load-bearing
- Wind resistance

Weather barrier
- Rain, snow, wind, sun, dirt dust pollution

Durability
- Moisture resistance, frost, mould
- Moisture Mass & Hygroscopicity
- Ozone and sunlight degradation

Thermal Performance
- Heat Resistance: loss and gain
- Condensation Avoidance
- Airtightness
- Avoidance of Thermal Bridges
- Thermal Mass
- Decrement Delay

Movement
- Structural , thermal, moisture, Frost
- Creep
- Chemical

Principles of Element Design

Acoustic Performance
- Resistance, absorption

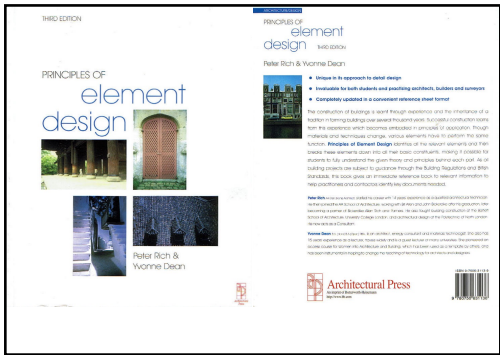
Fire Performance
- Fire Resistance
- Proximity to boundary

Security

Inspection and maintenance
- Inside & out

Biodiversity
- Inhabitation

Health
- Moisture Mass
- Low allergy materials



Pitched Roof Actions

Gravity: downward pull
Wind: Motive, Destructive, Penetrative, Scour, concentration of ballast and blow off roof
Rain: Moisture deposition, penetration
Snow: Moisture deposition, loading
Sun: Temp variation, thermal movement, solar radiation heat gains, Chemical decomposition
Dirt and Dust: infiltration, deposition, surface pollution
Chemicals: corrosion, disintegration, decomposition
Sound: Noise nuisance, from within and from without flanking from adjacent

Pitched Roof Reactions

Gravity: Support & restraint
Wind: rigidity, resilience, sealing, wind and air tightness, bonding/ fastening/ballast, high upstands
Rain: deflection, impervious skin, absorption and drainage, sealing
Snow: retention, deflection, impervious skin, absorption and drainage, sealing
Sun: reflection, albedo, thermal mass, decrement delay, movement joints, radiation, convection and conduction insulation, shielding, invulnerable materials
Dirt and Dust: repulsion, exclusion, shielding, collection, cleaning, demineralisation
Chemicals: invulnerable materials, exclusion, bio-remediation
Sound: Insulation

Principles of Roof Design

Roof form and types of weatherproof coverings
Structural strength and stability
  +ve and –ve pressure
Weather shield
Rain and other precipitation
Snow: Weight, Insulation, reflection, Slippage, melt water run off
Wind
  Wind driven rain, wind driven snow, wind scour of ballast, wind driven melt water,
Sun
  UV radiation
  Solar radiant Heat resistance
  Internal conduction insulation
  Overheating
Dirt and dust
Thermal performance
  Thermal movement
  Heat Gain and resistance
  Heat loss and retention
  Condensation risk

Drainage:
  Rain, snow melt water
  Pitch and materials
  Retention and Mitigation, SUDS
Durability
Sound Insulation
Maintenance
  External and internal, loading, safety
Security
  Entry through tiles and battens USA
Fire,
  External Fire Penetration
  Internal Fire Spread
Roof Access: Maintenance, cleaning, inspection,
Safety
Ventilation
Rooflights
  Privacy from overlooking
Insect exclusion or selective inclusion
Bat and Bird exclusion or inclusion

Principles of Element Design

Appearance
  Interior and exterior materials and finishes
Structural strength and stability
  Load-bearing
  Wind resistance
Weather barrier
  Rain, snow, wind, sun, dirt dust pollution
Durability
  Moisture resistance, frost, mould
  Moisture Mass & Hygroscopicity
  Ozone and sunlight degradation

Thermal Performance
  Heat Resistance: loss and gain
  Condensation Avoidance
  Airtightness
  Avoidance of Thermal Bridges
  Thermal Mass
  Decrement Delay
Movement
  Structural , thermal, moisture, Frost
  Creep
  Chemical

Principles of Element Design

Acoustic Performance
  Resistance, absorption
Fire Performance
  ___
  Fire Resistance
  Proximity to boundary
Security
Inspection and maintenance
  Inside & out
Biodiversity
  Inhabitation
Health
  Moisture Mass
  Low allergy materials

Design Considerations - Structure

What do we mean by structure?
Definition: 1.
- The arrangement of and relations between the parts or elements of something complex.

Synonyms:
- construction, form, formation, shape, composition, fabric, anatomy, make-up, constitution

Definition: 1.1 (mass noun)
- The quality of being organized

Typically, in the construction industry when we refer to 'structure' we are concerned with the sub-structure: foundations and superstructure: main frame of a building.
That which if removed would lead to a collapse of the assembly.
Humans without a skeleton would be a blob of skin and muscles

Approaches and Materials:
Heavy Framed:
  Concrete, Steel or Timber,
Each with infill or cladding.
Loadbearing:
  Masonry, CLTP, Sips, Light timber frame, light steel frame
Some with additional cladding
NB:
As architects and interior architects, we are not normally qualified to design structural frames.
Therefore, a Structural Engineer is required to design and we coordinate their design into our buildin.
Domestic buildings you might design the structure
Occasionally parts fall between/overlap disciplines

- Banham Group Headquarters, Thomsett Road, London
- Allies and Morrison

External Structure vs Architecture
Like a crustation (crab)
Shell is on the outside
Insitu concrete loadbearing walls and floors and roofs
Infill walls and windows

Salk Institute, Californai, USA Louis Kahn

Internal Basement Sub-Structure vs Architecture
Diaphragm basement walls reinforced with internal grid frame
Held apart by steel props
Heroic spaces
Coordination with escalators and landings treaded between props

Westminster Tube Station, London Hopkins Architects

Design Considerations – MEP

What do we mean by MEP?

1. Mechanical services focus on:
- Heating
- Ventilation
- Cooling
- Circulation (Lifts, Escalators)
2. Electrical services focus on:
- Power to all outlets, equipment & appliances
- Lighting
- Controls
3. Plumbing services focus on:
- Delivery of hot, cold and recycled water
- Draining of water and/or waste
- Distribution of Heating water or coolant
- Fire extinguishing

NB:
As architects and interior architects, we are not normally qualified to design building services.
Therefore, a Services Engineer is required and we co-ordinate their design into our building
In domestic work we might design and spec services.
Occasionally parts fall between/overlap disciplines

Banham Group Headquarters, Thornsett Road, London
Allies and Morrison

External MEP Strategy vs Architecture vs Structure

Structure and Envelope create a Services Zone
Services being outside need their own external envelop
And there will be lots of services/envelop penetrations
They need to perform as well as the envelop

Le Centre Pompidou, Paris, France Richard Rogers, Renzo Piano & Gianfranco Franchini

Internal MEP Strategy vs Architecture

Service mostly behind the ceilings and linings
Outlets, openings, pendulous parts exposed
Partitions need lateral restraints above ceiling
To resist internal wind pressure buffeting and people impacts and furniture/pictures hung on surfaces of partitions
They need be coordinated to avoid clashes with services

Banham Headquarters, London Allies and Morrison

Performance Requirements: Interstitial Condensation

Apart from keeping a building warm, dry, secure, etc., the external envelope needs to perform in an inherently ~~sound~~ competent manner.

~~Typically in buildings,~~ When warm, moist air comes into contact with cooler surfaces that are at or below the dew point, water condenses on those surfaces.

~~Every~~ material and system build-up has an inherent dew point where interstitial condensation will form.
A typical diagram above shows the dew point at approx 5 degrees C (celcius).
At this point, warm air vapour will turn to liquid.

A typical dew point table for a material/system

Performance Requirements: Heat & Moisture Condensation

Desktop studies can be carried out to calculate the point at which condensation will form within a given buildup under specific conditions.

The important variables include;
- internal air temperature
- external air temperature
- relative air moisture content

BS 5250 is a Static Method
- But buildings are subject to variable conditions:
- night to day
- summer to winter

Use WUFI or Delphin
- Hygrothermal moisture movement software

Red line is temperature, blue line is the dew point
If they cross 'here be dragons'

Performance Requirements

When interstitial or surfacce condensation happens within the building fabric and cannot dry out properly, mould will form.

This is bad for the building fabric, but more importantly, bad for human health.

Toxic mould kills and make building unusable without breathing apparatus

Interstitial (come to the surface) **Surface**
Examples of bad mould growth due to condensation

Performance Requirements: Thermal and Condensation

Temperature and dew lines never meet, therefore no condensation

Where temperature and dew lines meet, condensation will occur

Inadequate thermal insulation thickness shown in all three:
200mm: Plastics or 300mm Stone fibre to meet Building Regulations Approved Document Part L
Plus limiting thermal bridges and improving airtightness

Rainwater penetration occurs. Condensation can only occur in this insulated cavity wall if the warm air being pushed out from the inside is of high relative humidity and meets a cold enough surface to condense

Rainwater penetration and condensation can occur on inside of outer leaf, run down and into insulation to reduce its performance.
Exterior insulating render or room/house ventilation helps

Condensation can occur on inside of outer leaf and run down.
Ventilated cavity can reduce insulation performance.
~~Exterior insulating render or ventilation in cavity will help~~

Performance Requirements: External partial fill cavity wall

Blockwork inner leaf
Fire resistant partial fill cavity wall thermal Insulation
Cavity Closers and Fire stop
Window and windows sill (triple glazed today)
Window board

Typical cavity wall components
Brick outer leaf
Wall ties, Lintels, Cavity Tray DPC

Water drains down and guided out of cavity by lintels and cavity closing DPC Tray

External Envelope - Performance vs Architecture

Building Integrated PV panels
Zinc or Lead roofing
Risk of overheating

Large fixed Glazing
without solar shading
Risk of overheating and no passive cooling

Banham Headquarters, London
Allies and Morrison

External Envelope Preformance Checklist:

1. Structure-frame, stability, movement, lateral restraint,
2. Water-envelope: weather, precipitation, rain snow, wind blown rain, melting snow,
3. Thermal – envelope: k vlaues, U value, psi values (thermal bridges) Decrement Delay
4. Airtightness – envelope heat loss, colth gain, condenation risk, structural failures, ground gasses, radon, metane, air pollution,
5. Acoustic - sound control, external inwards, internal outwards, penetration, tansmission, absorption, reperberation
6. Fire - insulation and integrity, smoke and flaming droplets
7. Security - robustness, privacy, locking
8. Maintenance - access, repair, maintain, replace, de-constructing, re-assembling
9. Comfort – air temperature, surface temperature, ventilation, daylight, humidity, indoor air quality, VOCs CO_2, etc.

END OF LECTURE - KEEP WORKING ON YOUR DESIGN TASK

"We shape our buildings; thereafter they shape us."

Winston Churchill, Former British Prime Minister