



HEAT FLOW

This Week's Presentation

- > Next Week: *Environmental Design à Go-Go!*
New Trends in Europe
- > Review: Worksheet #5
- > **MEEB:** *Heat Flow;*
- > Worksheet #6;
- > **First Analysis Project (Review and Discussion)**
- > This Week's Media Material: *Green for All;*
- > **C+C:** *Putting Eco-Effectiveness into Practice*

So On With The Show!

Last Week: **Solar Geometry and Shading Devices** (Chapter 6)

Worksheet #5

... 1. The solar radiation spectrum includes:

(a) ultraviolet, visible, and infrared components

(b) only visible radiation

(c) infrared and visible components

(d) ultraviolet and visible components

Last Week: **Solar Geometry and Shading Devices** (Chapter 6)

Worksheet #5

... 2. Solar altitude is a measure of the:

- (a) angle between the sun's position and true south
- (b) angle between the sun's position and true north
- (c) angle between the sun's position and the horizontal plane
- (d) angle between the sun's position and the vertical plane

Last Week: **Solar Geometry and Shading Devices** (Chapter 6)

Worksheet #5

... 3. Solar azimuth is a measure of the:

- (a) angle between the sun's position and true south
- (b) angle between the sun's position and true north
- (c) angle between the sun's position and the horizontal plane
- (d) angle between the sun's position and the vertical plane

Last Week: **Solar Geometry and Shading Devices** (Chapter 6)

Worksheet #5

... 4. Which of the following statements best describes the relationship between clock and solar time:

(a) clock and solar time are generally within 10 minutes of each other throughout the year;

(b) clock and solar time are only different during Daylight Saving Time;

(c) in most geographic locations, clock and solar time differ throughout the year;

(d) the difference between clock and solar time is of concern only outside the US/Canada;

Last Week: **Solar Geometry and Shading Devices** (Chapter 6)

Worksheet #5

... 5. Which of the following statements best describes the relationship between solar south and magnetic south:

- (a) the difference between solar and magnetic south is never of importance to building designers;
- (b) magnetic and solar south are essentially identical in 90% of the US and Canada;
- (c) magnetic and solar south are always identical in North America;
- (d) magnetic and solar south can differ substantially in some geographic locales.

Last Week: **Solar Geometry and Shading Devices** (Chapter 6)

Worksheet #5

... 6. A sunpeg diagram is most commonly used with:

- (a) physical models of apertures and shading devices
- (b) computer simulations of shading device performance
- (c) hand calculations of daylighting factor
- (d) analyses of solar declination angle

Last Week: **Solar Geometry and Shading Devices** (Chapter 6)

Worksheet #5

... 7. Vertical and horizontal projection sun path diagrams are often used to:

(a) graphically show the impact of shading devices and solar obstructions;

(b) verify building code requirements for window assemblies;

(c) verify the output of computer simulations of daylight factor;

(d) orient physical models being used for shading studies.

Last Week: **Solar Geometry and Shading Devices** (Chapter 6)

Worksheet #5

... 8. A shading mask:

(a) is another name for an eggcrate shading device

(b) describes the path of shading as it tracks across a building interior space

(c) graphically shows the extent of shading provided by a given shading device

(d) is an overlay to the thermal comfort zone chart that accounts for solar radiation

Last Week: **Solar Geometry and Shading Devices** (Chapter 6)

Worksheet #5

... 9. A properly sized horizontal overhang that is exactly as wide as the south-facing window it shades will:

- (a) provide full window shading through all hours of the day;
- (b) provide full window shading only at solar noon;
- (c) provide no more than 50% shading at any hour of the day;
- (d) fail to provide meaningful shading at any time of day.

Project #1:
Design | Analysis | Design
Step 1

This week... Thermal Control | Solar Geometry and Shading Devices

Project #1: Design | Analysis | Design ***Schedule***

Discussed 27 Feb. Project Data and Discussion;

Due Today. Initial Structure Concept and Design;
Initial Sun Shading Solutions, including shade device;
Shading Mask for Shade Device.

Due for 12 March Initial Material Design for Opaque Walls;
Heat Flow Analysis for Opaque Walls.

Due for 19 March Initial Design Study of Transparent Elements;
Heat Flow Analysis for Transparent Elements;
Composite Envelope Heat Flow Analysis.

Due for 2 April Heating and Cooling Calculations;
Solar Savings Fraction.

This week... Thermal Control | Solar Geometry and Shading Devices

Project #1: Design | Analysis | Design

The Site: 3418 Roland Avenue, Baltimore, MD 21211
N39°19'45" | W76°37'58"



ACAD2000 file @ http://www.jkargon-architect.com/94_Project01-EnvSystems.html
Go to "SitePlan" link, right-click, and choose "Save Target As..."

Heat Flow (Chapter 7)

This week... Heat Flow

MEEB: What's Heat???

Heat is the flow of energy between two physical systems, each of which is at a different temperature.

Charles Gneiting, BPI



This week... Heat Flow

MEEB: Heat Flow and Environmental Design

By the true definition of heat, all “heat” is the flow of energy -- that is, the movement of energy from one thing to another.

In the context of Architectural Design (and, of course, Environmental Systems) the concept of “heat” may be embodied many different ways.

Examples?

This week... Heat Flow

MEEB: Heat Flow and Environmental Design

In the context of a building, the most obvious example is the flow of heat through the building “Envelope.”

Two ways we’ll examine are the movement of heat through the materials and assemblies of the walls and through the introduction of ventilation -- that is, the replacement of interior air with fresh, exterior air.

This week... Heat Flow

MEEB: The Building Envelope I

- > The exterior enclosure is assembled from a diversity of materials, each of which have unique thermal properties.
- > Some building elements are pre-assembled, with well-defined thermal behavior; others are site build, with the less controlled assembly methods.
- > Either way, envelope thermal analysis must ensure that the proposed assembly will meet the necessary codes and design performance criteria.

This week... Heat Flow

MEEB: The Building Envelope 2

- > The building envelope is not just a two-dimensional skin; “it is a three-dimensional transition space.” p.171

What kind of transitional activities or functions does the building envelope contain?

- > The building envelope exists in a fourth dimension, **TIME**.

*The dynamic character of buildings from day to night and from season to season affects not only the volume contained by the building envelope but also the physical make-up of the envelope itself. **Examples?***

This week... Heat Flow

MEEB: Building Envelope: Design Intentions

- > What makes up the building envelope?
Windows, Doors, Walls, Roof
- > Each of these includes sub components.
Window <> glazing, sash, blinds, drapes, &c.
- > Norberg Schulz, in *Intentions in Architecture*, suggests that elements of buildings can be re-conceived in terms of “its design intent relative to the exchange of energies: *as a filter, connector, barrier, or switch.*”

This week... Heat Flow

MEEB: Building Envelope: Design Intentions

- > *Connector*: A means to a direct connection
- > *Filter*: A means to an indirect (controlled) connection
- > *Barrier*: An element of separation
- > *Switch*: An element which can either stop or connect, depending upon control.

Among contemporary materials and assemblies, a new category might be added: Transformer.

This week... Heat Flow

MEEB: Building Envelope: Design Intentions

This suite of categories might itself be subservient to even wider-phrased design concepts.

Example: **Open Frame** building vs **Closed Shell** building

Why might a designer adopt one approach or the other?

Example: **Barrier Dominated** vs. **Connector Dominated**

How might these two categories relate differently to climate?

This week... Heat Flow

MEEB: Building Envelope: Design Intentions

These concepts are illustrated well by MEEB's examples of vernacular, traditional building types native to the Americas:



Igloo (Closed Shell)

Barrier to Wind
Filter to Light / Heat
Sparing Connectors...



Pueblo (Closed Shell)

Barrier to Wind and Light
Filter to Heat
Sparing, but Flexible,
Connectors...



Tipi (Open Frame)

Barrier to Rain
Open to Heat/Cold
Filter for Ventilation
Portable...



Palapa (Open Frame)

Barrier to Rain and Sun
Open to Heat and Ventilation
Often raised above ground to effect a spatial barrier to pests and floods...

This week... Heat Flow

MEEB: Building Envelope: Design Intentions

A focus on the use of “switches” in architecture affords a glimpse of building elements whose role is emphasized by the passing of time.

Examples: Daylight control devices (awnings or curtains)
Ventilation control devices (windows and fans)
Privacy control devices (shades and doors)
Passive Heating and cooling systems...

“Switches encourage interaction between (building) users and their environments. This is usually satisfying to the users, who are able to select the desired exposure to the climate at a given moment.” p. 176

This week... Heat Flow

MEEB: Sensible Heat Flow through Opaque Walls & Roofs

- > Flow of heat energy is always from Hot to Cold...
- > Heat flow through building Envelopes vary from season to season, depending upon whether the exterior is hotter than the interior, or vice versa.
- > As energy concerns rose in the last energy crisis (1970's), additional emphasis was placed on thermal performance. Unanticipated consequences of “tight buildings” included problems with IAQ. Additional ventilation requirements have addressed most of these issues; some issues, such as moisture retention, have persisted.

This week... Heat Flow

MEEB: Sensible Heat -- Some Terminology

- > Temperature: An indication of the extent of atomic excitation (vibration) in materials.
- > Latent Heat: The energy required to change the state of a material.
- > Energy: Amount of potential work.
- > Power: Energy per unit time.
- > Conductivity: Rate of Heat flow per unit thickness.
Conductance: Rate of Heat flow through an object.
- > Overall Coefficient of Heat Flow (U): Rate of Heat flow.
- > Resistance: Resistance to Heat flow
(Reciprocal of Conductance)

This week... Heat Flow

MEEB: Sensible Heat -- Some Units

- > Energy: Btu, Joule (SI -- *Systeme Internationale*), Watt-hour
- > Power: Btu/h, Watt (SI), HP
- > Heat Flow:
 - k Conductivity
 - C Conductance
 - h Surface Conductance
 - U Overall Coefficient of Heat Flow
 - R Resistance
 - M Permeance

This week... Heat Flow

MEEB: Sensible Heat Flow Concepts

- > Static versus Dynamic Heat Flow

Static heat flow is impacted by Resistance;

Dynamic heat flow is impacted by Heat Storage / Capacitance

- > Sensible vs. Latent Heat

Sensible Heat Flow results in a change in temperature;

Latent Heat Flow results in a change in state -- and, therefore, moisture content (ie, air humidity).

“Total Heat flow is the sum of sensible and latent flows. Materials react differently to sensible and latent heat flows.” p. 179

This week... Heat Flow

MEEB: Sensible Heat Flow Concepts

> Heat Flow Processes

Heat	Hotter to Colder;
Moisture	Greater concentration to lesser.

> Convection: Heat is exchanged between a solid and a fluid (typically air; or water).

> Conduction: Heat is exchanged from one material to another in contact.

> Radiation: Heat is exchanged via light.

This week... Heat Flow

MEEB: Sensible Heat Flow Concepts

- > Thermal Properties of Components

Conductivity

Rate at which heat will flow through a material, per unit;

Conductance

Rate at which heat will flow through a given quantity of material;

Resistance

How effectively a material insulates;

Emittance

How effectively a material radiates heat.

This week... Heat Flow

MEEB: Sensible Heat Flow Concepts

> Thermal Classifications of Materials

Insulations (Inorganic, Organic, and Metallic)

Materials which resist the flow of heat.

(May be used in Form-fitting / Flexible / Rigid forms.)

Conductors

Materials which allow the flow of heat.

(Are often dense, durable, and easily diffuse heat.)

Gaps (Air Films and Spaces)

When air flow is minimal, air films may act to insulate.

Air spaces must be kept tight to prevent air flow.

This week... Heat Flow

MEEB: Sensible Heat Flow Concepts

- > Composite Thermal Performance

U-Factor - *Overall coefficient of thermal transmittance.*

“Expresses the steady-state rate at which heat flows through architectural envelope assemblies.” p.184

U-Factor is the reciprocal of the sum of the resistances.

U-factor is a sensible heat property; U-factor does not address latent heat flow.

U-factor only describes conditions of air-to-air transfer through assemblies; air-to-ground transfer is different, due to earth conductivity.

This week... Heat Flow

MEEB: Sensible Heat Flow Concepts

- > Composite Thermal Performance: **Examples 7.1, 7.2**
- > Wall Assemblies
- > Roof Assemblies
- > Floor Assemblies
- > Doors

This week... Heat Flow

MEEB: Sensible Heat Flow Concepts

- > Special Envelope Heat Flow: **Examples 7.3, 7.4**
- > Slab-on-Grade Floors
- > Basements

This week... Heat Flow

MEEB: Sensible Heat Flow Concepts

- > Predicting Surface Temperature and Condensation:
Examples 7.5

This week... Heat Flow

MEEB: Sensible Heat Flow Concepts

> Dynamic Thermal Effects

Density

Specific Heat

Thermal Capacity

Time Lag

This week... Heat Flow

MEEB: Latent Heat Flow Through the Opaque Envelope

- > Latent heat flow is embodied in the movement of water vapor through the envelope.
- > In many climates, including our own, controlling the latent heat flow through the envelope has become a more critical issue than controlling sensible heat;
- > Different seasons bring with them different techniques for control, as well as opposing environmental circumstances; so that the control of the flow of latent heat may require several active responses, which vary throughout the year.

This week... Heat Flow

MEEB: Latent Heat Flow Through the Opaque Envelope

> *Moisture Control Fundamentals: “A difference in vapor pressure is the driving force behind moisture flow through components of an intact building envelope assembly, while gaps in the envelope can provide a route for airflow that carries water vapor.” p.193.*

> Analogy to Sensible Heat:

Permeance <> Latent Heat as Conductance <> Sensible;

Permeability <> Latent Heat as Conductivity <> Sensible;

> *“The less permeable a material is, the greater the resistance to water vapor flow.”*

This week... Heat Flow

MEEB: Latent Heat Flow Through the Opaque Envelope

- > **Vapor Retarders:** Materials with Low Permeance.

Typical practice in the US requires the use of Vapor Retarders in wall assemblies to control the flow of latent heat. The location of vapor retarders within wall assemblies remains the single most complicated and critical decision for architects.

The retarder must stop the infiltration of water vapor before it reaches a temperature point where it will condense -- ie, before it reaches its “dew point.”

This week... Heat Flow

MEEB: Latent Heat Flow Through the Opaque Envelope

> Cold Climate Moisture Control

Outside: Cold, dry Inside: Hot, moist.

Cold climate practice typically requires warm-side placement of vapor retarders.

This week... Heat Flow

MEEB: Latent Heat Flow Through the Opaque Envelope

> Hot Climate Moisture Control

Outside: Hot, humid Inside: Cool, dry.

Hot climate practice typically requires exterior placement of vapor retarders, including “drainage-planes” to deflect infiltration.

This week... Heat Flow

MEEB: Latent Heat Flow Through the Opaque Envelope

> Temperate Climates

Sometimes... Outside: Hot, humid; Inside: Cool, dry.

Sometimes... Outside: Cold, dry; Inside: Hot, moist.

Doh!

The key is to allow always pathways for trapped, condensed moisture to escape...

This week... Heat Flow

MEEB: Heat Flow Through Transparent/Translucent Elements

- > As we would expect intuitively, Transparent Elements (most often windows and skylights) have the lowest R (highest U) values among building components. (Improvements have been made, nevertheless.)
- > Transparent Elements often are the “leakiest” among building assemblies. They often allow greater uncontrolled air infiltration than continuous, opaque surfaces.

Discontinuity is the key concept in this regard.

This week... Heat Flow

MEEB: Heat Flow Through Transparent/Translucent Elements

- > Transparent/Translucent Elements allow in Light, and therefore contribute to:
 - Solar Heat in Winter (good) and in Summer (bad);
 - Daylight throughout the year (good);
 - Ventilation (when anticipated and controlled -- good);
- > Naturally, these elements also provide
 - Psychological Connection to the Outside (good);
 - Lack of Privacy (when unanticipated -- bad).

This week... Heat Flow

MEEB: Heat Flow Through Transparent/Translucent Elements

- > Types of Transparent / Translucent Elements:

*Windows, Skylights, Wall Panels (cf Kalwall),
Curtainwall/Storefront, Fabric Roof Assemblies*

- > Of the above, **Window** assemblies and **Curtainwall/Storefront** systems are the most highly rationalized and familiar to US construction industries.

In the US, windows may feature NFRC data including **U-Factor, Solar Heat-Gain Coefficient, Visible Transmittance, and Air Leakage.**

This week... Heat Flow

MEEB: Heat Flow Through Transparent/Translucent Elements

U-Factor

- > As with opaque materials, U-factor measure the coefficient of heat flow through all elements of the assembly, typically based on “conductive” heat transport.

Lower is Better; Greater is Worse.

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Solar Heat Gain Coefficient SHGC

- > “Represents the percentage of incident Solar Radiation (across the spectrum) which will be admitted by the assembly.” Includes effect of window glazing & framing.

Lower is Better; Greater is Worse.

[For circumstances where cooling loads are high, ie Summer]

Higher is Better; Lower is Worse.

[For designs where solar gain is desired, ie passive heating assemblies...]

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Visible Transmittance VT

- > How much visible light is transmitted at an angle perpendicular to the plane of the window. This is influenced by the material color of the glass, by coatings and films which are applied, and by the number of glazings. A high VT may not directly imply a high SHGC value; visible light may carry less heat than other light wavelengths.

Higher is Better; Lower is Worse.

[Where daylight and views are desired]

Where SHGC may be a concern, the LSG (Light-to-Solar-Gain Factor) describes the ratio of visible light to heat transfer.

Higher LSG is Better [Hot Climates]

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Air Leakage

- > Rate of outdoor air infiltration under “controlled” conditions, such as standard pressure (~ 25 mph wind), with the window locked.

Lower is Better; Greater is Worse.

Criteria might be varied (and the rated conditions increased) for “high-performance” windows...

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Low-Emittance (low- ϵ) Coatings

Coatings are applied to glazing face (typically within the air-space of multi-glazed assemblies) which control how heat energy is radiated from the surface of the glass. Doing so reduces the overall flow of energy through the assembly.

Lower is “Better” to resist energy transmission.

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Low-Emittance (low- ϵ) Coatings

- > Hard-coat (more durable, less \$\$\$, lower effectiveness)
- > Soft-coat (better performance, more \$\$\$, easier to damage during manufacture)

Three categories of Low-Emittance (low- ϵ) Coatings:

- > High Transmission, low- ϵ :
Coating on inner-glazing; lets heat through, traps it in...
- > Selective Transmission, low- ϵ :
Coating on outer-glazing; Low U, low SHGC, but high VT.
- > Low Transmission, low- ϵ :
Coating on outer-glazing; Low U, low SHGC, low VT.

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Low-Emittance (low- ϵ) Coatings

“Low E glass helps to reduce condensation on glass. The inside surface temperature of the glass is warmer. The differences can be dramatic. Imagine a cold night with an outside temperature of 0 degrees and a 15 mph wind. The inside temperature of a single pane window would be approximately 26 degrees. Regular double pane glass might register 35 degrees. Hard coat low E glass would be very near 49 degrees. And weighing in at champ would be soft coat low E glass at 62 degrees.”

http://www.askthebuilder.com/097_Low-E_Glass_-_It_Really_Works_.shtml

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Selective Transmission Films

- > Like low- ϵ coatings, allow the passage of some wavelengths and not others.
- > Applied either integral with the assembly (like coatings) or else to the exterior surface of glazing as a retro-fit.
- > May be selected for the desired thermal behavior. Films that allow visible light but reflect infra-red may be used either to maintain heat within buildings or prevent its entry.

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Inert Gas in the Air Gap

- > Argon or Krypton instead of air: Improved (lower) conductivity.
- > Optimum width for argon: 1/2"; for krypton (\$\$) : 1/4".
- > May be combined with low- ϵ coatings for improved performance.

Not for use in the vicinity of Superman!

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Superwindows!

- > Combination of multiple glazing, suspended films, coatings, inert gas-filled cavity, sealed/thermally broken frames...

Although high in costs, these assemblies might even perform better than the opaque wall in which they sit...

This week... Heat Flow

MEEB:Heat Flow Through Transparent/Translucent Elements

Shading

- > The most single performance- and cost-effective architectural feature affecting the thermal behavior of transparent elements.
- > Affects solar gain through **radiation**, not convection.
- > Location of Shading is crucial for the desired thermal performance. EXTERIOR shading best prevents the introduction of solar energy; INTERIOR shades help work against energy loss.
- > Shading may be operable or fixed.

This week... Heat Flow

MEEB:Trends in Envelope Thermal Performance

For 30 years, trends have improved the thermal performance of all building assemblies, either through increased material thickness or increased material performance. What other trends might we identify?

- > Structural Insulated Panels (SIP)
- > Aerogel, gas-filled panels, and compact vacuum products.
- > Additional improvements to Windows
 - Variable Light Transmission (Smart Windows)
- > Greater use of roof plane for heat collection or rejection.
- > Commissioning of the Building Envelope to enforce design and construction techniques.

This week... Heat Flow

MEEB: Heat Flow via Air Movement

The introduction of outside air into a building, while crucial for the health and comfort of its occupants, obviously presents a heating or cooling loads for interior environments which are usually maintained at a temperature different from the exterior.

- > **Infiltration:** Unintended introduction of outside air through the building envelope.
- > **Ventilation:** Deliberate, designed introduction of outside air.

All Ventilation must somehow be “conditioned”.

This week... Heat Flow

MEEB: Heat Flow via Air Movement

- > **Infiltration:** How to estimate its effects?
 - > *Air-change Method:*
Simple, quick, but often overestimates quantities.

“Observed performance is matched to key characteristics of a proposed building.”

$$V = \frac{\text{ACH (Air Changes per Hour)} * V \text{ (Building Volume)}}{60 \text{ min/h}}$$

“V” represents Infiltration Airflow Rate

This week... Heat Flow

MEEB: Heat Flow via Air Movement

> **Infiltration:** How to estimate its effects?

> *Crack Method:*

More methodical, and requires data on window/door construction as well as wind velocities. This method also assumes that all infiltration is due to cracks around windows and doors.

$V = L$ (length of window/door perimeter) * ALR (air leakage rate)

“V” represents Infiltration Airflow Rate

Actual air infiltration may be tested on a constructed building by means of a “blower door” test, in which a fan is mounted on an exterior door and air infiltration is noted by means of smoke entering the building through the sought-after cracks.

This week... Heat Flow

MEEB: Heat Flow via Air Movement

> **Ventilation:** What determines requirements?

ASHRAE Standard 61.1 (non-residential)

ASHRAE Standard 62.2 (residential)

Typically, required “V” for ventilation is a given factor times the number of occupants or total floor area.

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

- > Three types of flow are of primary interest:

Heat Loss based on “worst-hour” conditions -- used to size heating systems.

Design heat gain based upon “worst-hour” conditions -- used to size cooling systems.

Annualized heat flow, based on year-long climate -- used to predict annual energy usage and costs, as well as to predict compliance with energy standards.

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

> **Design Heat Loss** | Used to Size Heating Systems

“The greater the Design Heat Loss, the larger the required heating system capacity.”

DHL: “A statistically reasonable maximum heat loss quantity based on a chosen outside air temperature.”

Assumptions: At night, during the winter, no occupants, lights, or equipment to offset heat loss.

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

> **Design Heat Loss** | Used to Size Heating Systems

Required Information:

- 1) The **rate** at which heat flows through each of the building envelope elements. [Assembly U-factors]
- 2) The **area** of each of these assemblies.
- 3) The design **temperature difference** between inside and outside.

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

Design Heat Loss | Used to Size Heating Systems

- > Additional heat loss due to below-grade factors should also be considered.
- > The total design heat loss (sensible) is the sum of above-grade and below-grade losses.

It is, nevertheless, useful to create component categories for design heat loss so that improvements may be made in discrete ways related clearly to architectural decisions.

“Design for energy efficiency in the building envelope... consists of trying to reduce the value of any variable that occurs (in the design heat loss equation).” [p. 205]

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

Design Heat Loss | Used to Size Heating Systems

Design Palette: Array of choices from which you may select those which affect the total Design Heat Loss.

- > Reduce component U-factors, within the constraints of budget and constructability;
- > Reduce total areas of components by decreasing the “exposed surface” of the building design;
- > Reduce relative areas of components by favoring those with lower U-factors in place of those with higher;
- > Reduce the design temperature difference (ie, lower indoor air temperature).
- > Reduce airflow into the building.

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

Design Heat Loss | Used to Size Heating Systems

Latent heat loss is typically ignored during for heating-cycle calculations.

But latent heat loss may be calculated in a similar fashion, based on the relationship:

$$q = \text{Permeance} * \text{Area} * \Delta\text{Pressure} * (\text{enthalpy of latent heat})$$

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

Design Heat Gain | Used to Size Cooling Systems

DHG otherwise known as “Cooling Load”

The fact that the worst heating conditions occur during the day, when occupied, implies that simplifying assumptions similar to those for the DHL are not easy to make.

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

Design Cooling Load | Used to Size Cooling Systems

The following variables will affect design cooling load. These are also the “palette” of design factors:

- > Orientation of component assembly;
- > “Tilt” of the assembly;
- > Surface reflectance of the assembly;
- > Thermal capacity of an assembly;
- > Solar Heat Gain Coefficient of transparent assemblies;
- > Shading for any envelope component
- > Heat gain from occupants;
- > Heat gain from lighting;
- > Heat gain from equipment.

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

Design Cooling Load | Used to Size Cooling Systems

Difference between design heat gain and cooling load:

- > Heat gain is gross aggregate heat flow;
- > Cooling Load is total heat flow minus heat “stored” (by the internal mass of the building) plus residual stored heat previously introduced.

How is this calculated? *Doh!*

This week... Heat Flow

MEEB: Calculating Envelope Heat Flows

Design Cooling Load | Used to Size Cooling Systems

Sol-Air Temperature: *The apparent outdoor air temperature that would produce the equivalent heat flow due to actual air temperature and radiation.*

(Sort of the “wind chill” for heating on a sunny day.)

This is calculated by the sum of the ambient temperature plus the factor: $\frac{\text{Absorptance} * \text{Incident Solar Radiation}}{\text{Coefficient of heat transfer (infra red)}} - 7^\circ \text{F}$

This week... Heat Flow

MEEB: Envelope Thermal Design Standards

All local jurisdictions insist upon standards by enforcing building codes, such as ANSI/ASHRAE Standard 90.1.

Residential buildings may fall under IECC; ASHRAE also publishes residential standard 90.2

Most codes provide two “paths” to compliance:

- > **Prescriptive Path**, which lays out minimum material characteristics for each component or system;
- > **Performance Path**, which sets minimum levels of energy performance with no explicit reference to methods.

This week... Heat Flow

MEEB: Envelope Thermal Design Standards

Codes, especially prescriptive path-type codes, lay out only the **MINIMUM** standards for compliance; they establish legality, not desirability.

- > ANSI/ASHRAE 90.1 is the prerequisite for LEED, but to gain additional points towards the LEED rating, one must exceed ASHRAE 90.1 by 15% to 60%.
- > Codes do not address cost benefits which would be directly affected by improved energy performance.

Where costs and related factors will be of interest to the Owner, it is the design team's responsibility to present weigh options based on Heat Flow Analyses, among others.

This week... Heat Flow

Worksheet #6: Heat Flow (Chapter 7)

Viva la Rivoluzione!

PBS Video Series: *Design E²*

This week's showing: Green For All

This week... Cradle to Cradle: Chapter 6

Putting Eco-Effectiveness into Practice