ARCH 364: Building Science

"How to make buildings that work"* or "*How to practise architecture and not get sued"

Outline

- Scientific principles, economic, technical, and practical factors that influence *good design for physical performance* (durability, health, resource and energy efficiency) & thus sustainability of buildings will be studied. Principles of siting, shape, orientation and enclosure design from earlier courses will be briefly reviewed and integrated.
- The principles of good building science will be developed: an understanding of rain, air, heat, and condensation control, building material performance.
- The bulk of the course will focus on Canadian multi-unit residential, commercial/institutional buildings but different climate zones (such as hot-humid), and residential (multi- and single-family) will be mentioned.
- Common building enclosure assembly materials and designs will be explored through case studies of famous, local, unique, and vernacular building materials, details, sections, etc.
- Requirements for information on building drawings in schematic concept design (SD), design development (DD) and construction documents (CD) will be addressed.
- The interaction of HVAC, lighting, and other technical factors within the overall building design process to meet a range of goals will be integrated

The focus is on the needs of the professional architect, i.e., those involved in the design, rehabilitation, construction and operational aspects of buildings (heating, cooling, lighting, ventilation, maintenance) and the building enclosure i.e., walls, windows, roofs, foundations etc.

Lectures:

Wednesday: 9:00 to 11:50 PM ARC1101

Format

Lectures, slide shows, case studies, practical design and review problems. Some simple equations, mostly concepts and design principles.

Marks will be assigned through:

- Assignments (2*10% =20%)
- pop quizzes / in-class exercises (20%)
- a final enclosure detailing project (30%), and
- a 2.5 hour final exam (30%).

This class is assumed to be as important as other classes and studio and *attendance is expected*. The final project will be handed in at the end of classes and aims to integrate the term's studio project. It will be assigned in the final month. Final exam has not yet been scheduled.

Note: All assignments must be bound (with staples or better – no paper clips) have a separate cover page with the students' full name and ID# clearly written or typed. One warning will be

issued, after which the assignment *will be marked out of half*. Assignments are to be submitted into the box in front of main office.

Reference Materials and Prerequisites:

Required textbook *High Performance Building Enclosures*, by John Straube, Building Science Press, Somerville, MA, 2012. 978-0-9837953-9-1 Sold/delivered in class at a discount (incl shipping). We will be using example drawings and calculations from the text throughout the term, and assigning reading from this text.

It is assumed that you have taken the ARCH building technology courses and hence have a copy of, and understand, *Fundamentals of Building Construction*, by Ed Allen (any edition) e.g. Wiley, 2013, ISBN 0471219037 or newer.

Extensive Web notes (via the Desire2Learn site) will be provided. Required (tested and discussed in class) readings will be assigned in class.

Instructor:

Dr John Straube
Office: Waterloo Campus CPH-2373H
E-mail: jfstraube@uwaterloo.ca (preferred method)
Telephone: 5197417920 (cell)

Rules and Regulations

Late Policy. Assignments will lose 20% of possible marks if late and 10% per day for each additional calendar day that a project or assignment is late. *All course work must be submitted by the final day of exams in the term in which the course is taken or will be given a mark of zero.*

Missed Quiz/Exam. Student who miss quizzes must have a doctor's note or equivalent. Plan to be present in school during the official final exam period. *Student travel plans are not considered acceptable grounds for granting an alternative examination time*

Academic Integrity and Plagarism: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. It is the student's responsibility to inform themselves of what constitutes plagrism. Proper references to other peoples work are required, especially when you are presenting work or ideas as your own. Never submit drawings that are based on the digital files of others—components taken from specific manufacturers' websites are acceptable but should be referenced. [Check www.uwaterloo.ca/academicintegrity/ for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please be certain to contact the School's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity [check www.uwaterloo.ca/academicintegrity/] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities: The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.

Rough Outline

This course's intention is to be flexible and responsive to student needs (e.g. concurrent studio class) and interests, but the plan outlined below will be a guide to the course. Deviations from this are certain to occur and the timing always adjusts with class progress.

Introduction: Why Building Science

- Building Industry
- Large, local, disaggregated
- Different roles of buildings: investment, productive tool, statement
- Building performance is generally poor. Consider energy

- Architects Role
  - Division of labor, concept design, working drawings, site visits, etc
  - Environmental concerns
  - Now it is performance: quantifiable, measurable
  - Building cost vs operating cost
  - Evidence-based design. Science. Technology.
- Building Review Assignment

The Broad Strokes (Building)

- Building components
  - Relative Costs for high rise examples
- Building shape, massing= efficiency of cost, materials, energy etc., daylight access
- Durability strategies: What makes materials good bad?
  - Support for Perfect Wall theory
  - Deterioration mechanisms to consider Heat/cold, moisture, UV, fire, fatigue
  - rain, condensation (material selection for UV, cold, hot, wet)
- Energy efficiency strategies
  - Shape and orientation
  - airtighten
  - insulate,
  - control sun,
  - daylight

Building Enclosure and Context

- Building Enclosure
  - Functions: support control finish
  - History, specialization of structure, etc
- Perfect Wall intro
  - Control layers: brief intro
  - Example of Functional

Technology and Practise

- Building Enclosure Technology Constraints
  - Combustible vs non-combustible
  - High-rise vs low-rise: access, , weight, costs, prefab, weather
- Review of options, functions, materials

Enclosure Design

- Perfect Wall Redux
- Control layers in depth
  - Water

    - Air
    - Thermal
    - Vapor
- Materials / assemblies that form control layers
- Continuity: the architects most important job

Thermal control - general

- Why control?
    - Comfort,
    - condensation,
    - energy
- How? Review
    - Insulation,
    - airtightness,
    - solar control (color, low-e, shade)
- Calculating heat flow
    - R-value, conductivity, rating insulations
    - 1-D wall/roof
    - 3-D box

Thermal Control- Insulation

- Calculating heat flow
- Pros and cons of different insulation materials/systems
- Thermal bridging

Air Control

- Why control air: health, comfort, efficiency, condensation
- Layers (sub-assemblies) and materials
- Details
- Testing

Vapor control and condensation

- Moisture in air = vapor. Psychrometrics
    - condensation
- Vapor transport: convection and diffusion
- Air barriers vs vapor barriers
    - When /where do you use vapor barriers
    - When /where do you not use vapor barriers
- Drying

Rain Control: the most important

- Most important control function since Vitruvius, still getting sued
- Building level exposure assessment – how much control do you need
    - Climate, site, shape, façade details, overhangs
- Enclosure Design approaches
    - Drained, mass, perfect

Windows and Curtainwalls

- Brief History of Glass
- Types of systems
    - Windows
    - Curtainwalls and storefronts
    - Window walls

    - IGU's
    - Double Facades
- Choosing /specifying
    - Performance metrics
    - R-value
    - Solar Control
    - Daylight
    - Rain control
    - Maintenance and Durability