

TOPICS IN SUSTAINABLE-BUILDING SCIENCE

[MECH 550B, CIVL 592x, RMES 500x]

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PREAMBLE

This course is the introductory course for students in the *Sustainable Building Science Program*. In view of the diverse backgrounds – natural sciences and engineering, health and social sciences, architecture, etc. – of the students who may register in this course, it is not reasonable to assume that a very deep understanding or quantitative analysis of all building science and sustainability areas can be covered. Rather, emphasis will be on providing a high-level conceptual/qualitative understanding of sustainability and the building design and construction processes and players, the integration and inter-dependency of the various building systems and their designs, the potential conflicts between them, and how this understanding can inform design decisions to create buildings exhibiting a higher level of performance, including a high level of sustainability.

COURSE OVERVIEW

This course will be offered at the graduate level, open to students in the natural sciences and engineering, health and social sciences, architecture, etc. interested in learning how to create better, more sustainable buildings. It will normally be a required course for student trainees in the *Sustainable Building Science Program*, and an elective for other students. Motivated students in their final year of an undergraduate program may be permitted to take the course as an elective (with slightly less demanding requirements for course evaluation).

The knowledge required to understand the objectives and processes of sustainable building, how inhabitants interact with buildings, how quality is defined and evaluated, and of building systems, will be delivered through a variety of means: lectures from specialists, assigned readings, comparative case studies, and site visits. The students will develop a qualitative understanding of the topics below at the depth necessary to understand key issues and identify relationships, with a focus on sustainable building.

COURSE LEARNING OBJECTIVES

1. To gain a basic understanding of the natural, health and social science and engineering issues associated with the design, construction and operation of (sustainable) buildings – that is, of (sustainable-) building science.
2. To understand the relationship between building inhabitants and building systems.
3. To understand the (sustainable-) building design and construction processes and stakeholders.
4. To become familiar with building drawings, and apply this knowledge to the analysis, critique and comparison of two contrasting UBC buildings through their drawings.
5. To understand issues of sustainability and the contribution of buildings, and be able to analyze a building's performance according to a number of sustainability indicators, recognizing their dependence on one another.
6. To understand the various systems that all building must contain in order to function successfully, to identify the respective professionals responsible for the design of each, and to be able to identify the inter-relationships and dependencies among these various systems.
7. To understand the importance of establishing building performance criteria for each of the building systems at the design stage, and how to evaluate performance through the analysis of post-occupancy performance data.

8. To understand the importance of approaching building design using an integrated design process (IDP) involving all design consultants, in order to attain high levels of performance through the appropriate integration of all building systems.
9. To apply the knowledge learned to real-world buildings.

COURSE FORMAT / EVALUATION

The students will meet twice weekly for 1½ hour sessions. Each class will nominally involve a 1-hour lecture on a topic, supplemented by a ½-hour discussion.

Discussions will be based on applying the knowledge gained in the lectures, from drawings and site visits, to two UBC buildings.

Students will be evaluated on the basis of in-class participation (10%) and essays submitted each week analyzing, critiquing and comparing the two buildings with respect to the topic of the previous week's lectures (90%).

COURSE CONTENT / OUTLINE

A SETTING THE STAGE: OBJECTIVES, PARTNERS, PROCESSES, PREDICTION, EVALUATION

This first phase of the course will identify the overriding issues which are common to all building design and construction projects and their technical concerns, and will form the basis for analysis and discussions. This phase will last 7 weeks.

A1 INTRODUCTION TO SUSTAINABILITY, SUSTAINABLE BUILDING, ARCHITECTURE Cole, Robinson (1½ hour – Week 1a: Sept 13)

What do we mean by “buildings”; what comprises the building industry that creates, maintains and operates them?

- what is the role of the building as part of the community?
- how does the building as a financial asset come into play?

What do we mean by building science (natural, health and social sciences, engineering)?

What do we mean by sustainable, green?

- climate change, greenhouse gases, carbon emission, sequestration, ozone depletion, global warming, material and energy consumption, water resources, inhabitant satisfaction

What role do buildings have with respect to sustainability?

Overview of the building process (cradle to grave): pre-design phase; design phase; construction phase; occupancy and post construction phase; demolition/re-use

- responsibility, risks of building designers
- current trends in, and the future of, architecture

A2 INTERACTION OF PEOPLE WITH BUILDINGS

Robinson, Bartlett (3 hours – Week 1b: Sept 15, Week 2a: Sept 20)

- building inhabitants; how do people interact with buildings?
- passive and active systems, and controls
- components of the building indoor environment and indoor environmental quality.
- creating environments for the habitation of people with conditions of optimum physical and psychological comfort, health, ergonomics, productivity
- how do we characterize conditions of human health and comfort?
- how do we ensure comfort conditions are maintained in buildings?

A3 BUILDING SYSTEMS

Johnson (1½ hour – Week 2b: Sept 22)

How can we break the building down into comprehensible systems?

Typical classification system:

- site system (civil, water supply, sanitary sewer, storm sewer, electrical, data, energy)
- building structure
- building enclosure (envelope)
- building services (HVAC, lighting, data, power, water, waste, fire protection, egress, vertical circulation)
- interior finishes and furnishings

Active vs. passive systems

How do these systems interact?

A4 CREATING THE BUILDING

The Building *Design* Process

Johnson (1½ hour – Week 3a: Sept 27)

Description, importance of the Integrated Design Process (IDP)

Partners involved: architect; structural; mechanical (plumbing, HVAC, fire protection); electrical (power, data, lighting); civil (services, site issues); landscape architect; cost consultant; specialty consultants (acoustic, theatre, commercial kitchen, etc.)

Typical phases of design:

- pre-design, charrettes
- schematic design
- design development
- construction documentation
- tendering
- construction administration

Regulations, codes, standards

Drawings, technical specifications, contractual documents

How to interpret construction documentation

Documentation; Case Studies

Johnson, Hodgson (1½ hour – Week 3b: Sept 29)

- case studies of two UBC buildings; drawings; course assignments
- site visits

The Building *Construction* Process

Froese (1½ hour – Week 4a: Oct 4)

Description, importance of the Integrated Construction Process (ICP)

Typical phases of construction: pre-construction; construction; commissioning; occupancy

Construction procurement methods: stipulated sum; cost plus; construction management; project management; design-build

A5 OPERATING THE BUILDING: PREDICTING and EVALUATING BUILDING PERFORMANCE

McCarry?, Sianchuk?, Coleman? (3 hours - Week 4b: Oct 6, Week 5a: Oct 11)

Codes and standards

Economic impact (dependent on particular economic environment, cost of money, general and energy inflation rates, time factor)

How to establish the criteria used to evaluate a building's performance?

Building performance certification schemes/benchmarks:

- LEED, BREEAM, Green Globes, PassivHaus, Energy Star, etc.

Life Cycle Assessment (LCA)

Net Zero Energy buildings

Use of building design, performance assessment software

Impact over time, adaptability and flexibility of a building to suit a changing program

Durability of components, robustness

Social and cultural impacts (aesthetics, social capital)

Post Occupancy Evaluation (POE)

Results of existing evaluation studies – how are we doing?

A6 MATERIALS USED IN THE BUILDING

Banthia, Lam, Connelly (3 hours – Week 5b: Oct 13, Week 6a: Oct 18)

Importance of selection of materials to be used in the building (initial materials, repairs, replacement), durability and need to replace. Selection based on potential for recycling, re-use?

Life-cycle assessment (LCA) of building materials

Overview of materials: concrete (cast-in-place, pre-cast); masonry (clay, concrete, straw bale); rammed earth; wood (natural and engineered); metals (steel, aluminum, copper, zinc, lead, etc.); glazing; synthetic (plastics, acoustic, etc.); composite materials; vegetation (green roofs and walls)

A7 ENERGY USED IN THE BUILDING

Frisque, Bushe (3 hours – Week 6b: Oct 20, Week 7a: Oct 25)

Energy used in many phases of building's life: sourcing and manufacturing of materials; construction; operation; maintenance and to accommodate replacement of materials; demolition and disposal

Types and quality of energy used, energy transportation costs

Building energy design concepts and modelling

- active vs. passive systems
- Net Zero Energy buildings

Potential on-site energy generation: solar; wind; geothermal exchange

A8 SYNTHESIS

Hodgson, Johnson (1½ hours - Week 7b: Oct 27)

B THE TECHNICAL ISSUES

This second phase of the course will focus on the individual technical issues or systems of buildings. Though they are compartmentalized, there will obviously be considerable overlap and conflicts from one to the next, and discussions around the inter-relationships and conflicting requirements will be encouraged. This phase will last 6 weeks.

B1 STRUCTURE and ENCLOSURE

Tariku (1½ hours - Week 8a: Nov 1)

Structure must provide for the safe and stable physical containment of the building spaces, resistant to external forces (vertical, lateral constant, cyclical).

Both structure and enclosure must be comprised of durable components appropriate to the use and anticipated building lifetime.

The building enclosure provides control over the movement of mass: air; moisture (water in liquid and gaseous forms); and energy: light; heat; fire; sound.

The design of the building enclosure has a major impact on the energy performance and long-term durability of the building, and must address the particular exterior climatic conditions.

B2 THE THERMAL ENVIRONMENT

Tariku (3 hours – Week 9a: Nov 8, Week 9b: Nov 10)

In order to control the thermal environments, must determine the conditions which meet the requirements of thermal comfort

Strong relationship between thermal control and ventilation strategies

Factors which impact thermal comfort: ambient air temperature; air movement; air moisture content; radiant temperatures and solar gains into spaces; thermal mass/capacitance

How are these factors controlled with passive or active systems?

B3 THE AIR ENVIRONMENT and VENTILATION

Rogak, Atabaki, Bartlett (3 hours – Week 10a: Nov 15, Week 10b: Nov 17)

Must establish requirements for air quality, VOC, O₂ and CO₂ levels, aerosol, particulate matter in the air, etc.

Atmospheric quality is dependent on materials used (interior finishes/furnishings most significant).

Must establish relationship of atmospheric quality to natural and forced ventilation, air circulation and air change rates.

Understand principles of forced (mechanical), natural ventilation, displacement ventilation and their effectiveness.

Overview of the design of the HVAC system:

- system types, circulation rate, ventilation rate
- heat recovery
- thermal control

B4 THE VISUAL ENVIRONMENT

Whitehead (3 hours - Week 11a: Nov 22, Week 11b: Nov 24)

Appropriate combination of natural and artificial illumination

Illumination levels, attention to glare, reflections, colour spectrum, controls, etc.

Daylight and sunlight capture devices

Day lighting, fenestration ratio, and effective R-value envelope for thermal control

Impact of the approach to lighting the building on energy use

B5 THE ACOUSTICAL ENVIRONMENT

Hodgson (1½ hours - Week 12a: Nov 29)

How do we characterize sound; sound vs. noise?

Sound absorption, propagation, attenuation, transmission

Room/building acoustics: sound level, reverberation, noise isolation

Acoustical environments and inhabitants: comfort, speech intelligibility/privacy

Acoustical design; sound-management strategies

B6 BUILDINGS AND WATER

Nosini?, Civil?, NovaTech? (1½ hours - Week 12b: Dec 1)

- water supply
- rainwater
- plumbing (sanitary, storm, greywater systems)

B7 SENSORS AND MONITORING SYSTEMS

Walus, Stoeber, Chu, Honeywell (1½ hours - Week 13a: Dec 6)

B8 SYNTHESIS (Panel discussion), COURSE WRAP-UP

Hodgson et al. (1½ hours - Week 13b: Dec 8)