ARCH 594 2025FA

High Performance Building Design

FALL 2025
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Instructors: **Yun Kyu Yi**, Ph.D., Associate Professor
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Credit: 3 credits

Class Days/Time: Tuesday 8:00 AM - 10:50 AM CT.
Architecture Building 4W or Zoom

Office Hours: by appointment

Course Description

The class applies simulation and diagramming techniques to a design project at different scales. The emphasis is on refinement and optimization of performance-based building design. Performance analysis techniques can provide enormous amounts of information to support the design process, acting as feedback mechanisms for improved performance, but the careful interpretation and implementation are required to achieve better buildings. Energy, lighting, and airflow are the three main domains covered in the workshop.

Overall Course Goals or Student Learning Objectives

This course is one of a graduate elective course for Technology and Performance. The primary goals of this course are to introduce students to theoretical and analytical approaches to evaluate building performance through computational simulation. Students will learn how to utilize computational tools at an advanced level, and utilize them as applications to examine an existing building. Using the results of analytical techniques, the students will develop sustainable design strategies.

Course Content Learning Outcomes

- Observe, Analyze and diagram existing building indoor condition with using sensors and meter data.
- Build and simulate an existing campus building's whole-building energy model.
- Calibrate whole energy model to reflect actual building energy use and analyzing energy usage and finding problems.
- A proposed design solution to improve energy usage and indoor comfort.
- The test proposed design strategies and find its performance.

- Represent your work to successfully communicate your findings to a professional audience of faculty, students, and architects.

Upon successful completion of this course, you will be able to:

- Learn how to use computational building simulation tools.
- Learn how to analyze building performance.
- Learn how to test and evaluate the proposed design with the support of computational simulation tools.

Technology Requirements for this Course

This course requires the use of a laptop computer that complies with the hardware specifications that were communicated to you by the Admissions Office when you enrolled in the program. This course will require your use of the software applications in ClimateStudio, DesignBuilder. It is your responsibility to ensure you have a working computer with the required software installed and functional for this course.

READING LIST/ BIBLIOGRAPHY /Additional Resources

- Malkawi, Ali M. and Augenbroe, Godfried, ed. Advanced Building Simulation. New York: Spon Press, 2003. Chapter 2*
- John A. Sokolowski, Catherine M. Banks, ed. Principles of Modeling and Simulation: A multidisciplinary Approach. Wiley, 2009, Chapter 6, & 7*
- Yehuda E. Kalay, ed. Evaluating and Predicting Design Performance. Wiley, 1992. , Chapter 2, & 3*
- Greg Ward Larson and Rob Shakespeare, Rendering With Radiance: The Art And Science Of Lighting Visualization, Booksurge Llc; Revised edition (April 26, 2004),
- Energy Plus. Input Output Reference. US Department of Energy pp1-pp160
- Energy Plus. Getting Started with EnergyPlus. US Department of Energy
- Energy Plus. Engineering Reference. US Department of Energy pp22-82
- ANSYS , ANSYS FLUENT 12.0, Getting Started Guide. 2009
- ANSYS, ANSYS FLUENT 12.0, Tutorial Guide. 2009
- Steven Ternoey and others. The Design of Energy-Responsive Commercial Buildings. Wiley.
- Yi Yun Kyu, Malkawi Ali, "Integrating neural network models with computational fluid dynamics (CFD) for site-specific wind condition," In Building Simulation An International Journal, Tsinghua University Press and Springer-Verlag Berlin Heidelberg, Vol. 4:245-254, 2011
- Yi Yun Kyu, Malkawi Ali, "Site-Specific Prediction for Energy Simulation by Integrating Computational Fluid Dynamics," In Build-ing Simulation An International Journal, Tsinghua University Press and Springer-Verlag Berlin Heidelberg, Vol. 1(3):270-277, 2008.

Tentative Course Schedule

Week 1/ **Introduction**

Project introduction

TASK (Homework)

- Visit potential buildings
- 24hours of energy consumptions
- Install DesignBuilder

Week 2/ **Whole Building Energy Modeling I**

Tutorial on DesignBuilder
TASK (Homework)

- Develop Site Plan (include whole block, adjacent buildings, sidewalks, trees)
- Develop Building Elevations; one for each façade, include adjacent buildings,
- Develop Building Plans
- Develop Building 3d Model with adjacent buildings
- All drawings in Rhino
- Schedule a site visit

Week 3/ **Whole Building Energy Modeling II**

Tutorial on DesignBuilder (Geometry and Material)
Progress report by each team

- Drawing developments by each team
- Requiring building information
- Method to acquiring information

TASK (Homework)

- Finish all required drawings
- Site visit
- Simple exercise assignment

Week 4/ **Whole Building Energy Modeling III**

Tutorial on DesignBuilder (Geometry and Materia)
Progress report by each team

- Building survey

TASK (Homework)

- Initial DB modeling (geometry, material)

Week 5/ **Whole Building Energy Modeling IV**

Tutorial on DesignBuilder (Zoning and System)
Progress report by each team

- Progress on DB modeling (geometry, material)

TASK (Homework)

- DB modeling (zoning, geometry, material)

Week 6/ **Whole Building Energy Modeling V**

Tutorial on DesignBuilder (System and Schedule)
Progress report by each team

- Progress on DB modeling (Zoning and System)

TASK (Homework)

- DB modeling (System and Schedule)

Week 7/ **Whole Building Energy Simulation I**

Tutorial on DesignBuilder (Daylighting and Lighting system)
Progress report by each team

- Progress on DB modeling (System and Schedule)
- Initial Simulation result report

TASK (Homework)
- Correct DB model

Week 8/ **Whole Building Energy Simulation II**
Tutorial on DesignBuilder (Energy Analyis)
Progress report by each team
- Simulation result report
- Comparison with real meter data

TASK (Homework)
- Correct DB model

Week 9/ **Whole Building Energy Calibration I**
Tutorial on DesignBuilder (as needed)
Progress report by each team
- Initial calibration result

TASK (Homework)
- Second round calibrations

Week 10/ **Whole Building Energy Calibration II**
Tutorial on DesignBuilder (as needed)
Progress report by each team
- Update calibration result

TASK (Homework)
- Third round calibrations

Week 11/ **Whole Building Energy Calibration III**
Tutorial on DesignBuilder (as needed)
Progress report by each team
- Update calibration result

TASK (Homework)
- Forth round calibrations (if needed)

Week 12/ **High Performance Design I (Final Project)**
Progress report by each team
- Update calibration result

TASK (Homework)
- Design strategies

Week 13/ **High Performance Design II (Final Project)**
Progress report by each team
- Proposal on design chages

TASK (Homework)
- Testing Design proposal using DB

Week 14/ **Holiday**

Week 15/ **High Performance Design III (Final Project)**
Progress report by each team

- Initial test results

TASK (Homework)

- Preparing Final Report

Week 16/ Final Presentation