CAE 463/524: Building Enclosure Design

Spring 2015

Illinois Institute of Technology
3 credit hours
Department of Civil, Architectural and Environmental Engineering

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Course Unique Number(s)
CAE 463 Section 1: 26562 (undergraduate); Section 2: 26563 (undergraduate online)
CAE 524 Section 1: 26766 (graduate); Section 2: 26767 (graduate online)

Classroom and Meeting Time
Engineering 1, Room 032
Tuesdays, 5:00 PM – 7:40 PM

Course Website
http://built-envi.com/courses/cae-463524-building-enclosure-design-spring-2015/

Prerequisites
CAE 331 Building Science

Instructor
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Built Environment Research Group | Website: www.built-envi.com

Office Hours
Office hours are by appointment only. Please email me to schedule an appointment.

Course Catalog Description
Design of building exteriors, including the control of heat flow, air and moisture penetration, building movements, and deterioration. Study of the principle of rain screen walls and of energy conserving designs. Analytical techniques and building codes are discussed through case studies and design projects.

Instructor's Course Objectives and Learning Outcomes
To introduce students to the design of building enclosures, elements of which include walls, floors, roofs, and intentional openings. By taking this course students will be able to:

1. Design and assess building enclosure elements for heat transfer, airflow, and moisture control.
2. Be proficient in current building codes and standards as they pertain to building enclosure design.
3. Critically analyze designs for advanced building enclosures for their impacts on energy use, airflow, and potential moisture issues.
4. Be proficient with several software tools used in building enclosure design.

Textbook (recommended but not required)
I recommend this book as an excellent resource for general building science and enclosure design topics:

Straube, J. and Burnett, E. 2005. *Building Science for Building Enclosures*. Building Science Press. ISBN: 0-9755127-4-9.

However, **this text does not appear to be available** any more! You will not need to attempt to purchase it.

Other references (optional; will be given all handouts when necessary)
In addition to the aforementioned textbook, I will also rely on several other materials in this course. These materials are optional for the student; handouts will be given when necessary so that no one is required to purchase these items.

Aksamija, A. 2013. *Sustainable facades: design methods for high-performance building envelopes*. John Wiley & Sons. ISBN: 978-1-118-45860-0.

ASHRAE 2009. *Handbook of Fundamentals.* American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

ASHRAE 90.1-2010. *Energy Standard for Buildings Except Low-Rise Residential Buildings.*

Janis, R.R. and Tao, W.K.Y. 2009. *Mechanical and Electrical Systems in Buildings*. Pearson Prentice Hall. ISBN: 978-0-13-513013-1.

Kuehn, T.H., Ramsey, J.W., and Threlkeld, J.L. *Thermal Environmental Engineering*. Prentice Hall. ISBN: 0-13-917220-3.

Kreider, J.F., Curtiss, P.S., and Rabl, A. *Heating and Cooling of Buildings: Design for Efficiency* (Second Edition), CRC Press, Taylor & Francis Group. ISBN: 978-1-4398-1151-1.

McQuiston, F.C., Parker, J.D., and Spitler, J.D. 2005. *Heating, ventilating, and air conditioning: analysis and design*. John Wiley & Sons, Inc. ISBN: 0-471-47015-5.

Moss, K.J. 2007. *Heat and Mass Transfer in Buildings* (Second Edition). Taylor & Francis. ISBN: 978-0-415-40908-7.

Homework Assignments
There will be several homework assignments during the course that will involve a combination of hand calculations, development of spreadsheets, and learning the basics of some software packages typically used in industry. Some general rules for homework assignments are as follows:

- Homework (HW) assignments will be posted online.
- HW assignments will typically be due one week after they are assigned.
- Either electronic PDF copies of HW or hardcopies are acceptable. If submitted electronically your file should be in pdf format and the filename should be in the format of **hw1_lastname_firstname.pdf**.
- Hardcopy HW assignments should be neatly printed.
- Multipage submissions of any hardcopies must have all pages stapled together.
- Students enrolled in the online course will submit HW via email to the instructor. Handwritten HW must be scanned and converted to PDF by online students. Multiple pages must be converted to a single PDF for submission.

Late Homework Policy
Homework is due at the beginning of class on the day that it is due. Do not work on HW during the lecture. Late HW will receive a 10% reduction in the total score per day late, excluding weekends. For example, a HW due on a Monday turned in the following Monday will have its grade reduced by 50%.

Exams
One take-home exam will be given with a tentative date of March 24, 2015 due March 31, 2015. A final exam is not scheduled for this course. A final project presentation is currently scheduled to take place the last week of classes (April 28, 2015); final project reports will be due May 5, 2015.

Projects
There will be two projects in this course. The first is a building enclosure assessment group project where class members will work together to critically assess the building enclosure of a building on IIT's main campus and to suggest improvements for increased energy and moisture performance without changing

the aesthetics of the building. The project will involve visual assessment and performance testing (i.e., thermal imaging, heat flux measurements, surface temperature measurements, and/or blower door testing) of a chosen campus building.

The second project is an individual research and design project where students will explore enclosure designs or constructions that claim to be "high performing." Students will utilize the tools and techniques learned throughout class to critically analyze an enclosure design for its likely performance in terms of heat transfer, airflow, and moisture transport. Students will explore enclosure designs/technologies primarily through peer-reviewed academic and technical literature, manufacturer product literature, case studies, conference papers, and/or trade publications. Students will present findings in a technical report and in a final oral presentation and will use this information to present a design of their chosen type of enclosure for a hypothetical building. Graduate students are expected to perform a more detailed analysis and format their report as a more formal research article/conference paper.

Grading

Course grading will be done primarily through homework assignments, one exam, the campus assessment project, and your final projects. This is a mixed undergraduate and graduate course; higher expectations will also be placed upon deliverables from graduate students. Grades will be determined by the total number of points accumulated through homework assignments, projects, and exams, with a small amount of credit for class participation. The total number of points available in each category is listed in the table below. The percentage of total points required for various letter grades is also given below.

Grading	HW	Exam	Campus project	Final project	Total
All students	250	250	250	250	1000

Grading scale	A	B	C	D	F
All students	90% and up	80.0-89.9%	70.0-79.9%	60.0-69.9%	<60.0%

Personal Problems

If you have illness or personal problems that will affect your performance during the course of the semester, please let me know as soon as possible. "After the fact" provides little protection unless there are extreme circumstances. Contact me by phone or e-mail at any time.

Students with Disabilities

Reasonable accommodations will be made for students with documented disabilities. In order to receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources. The Center for Disability Resources (CDR) is located in 3424 S. State St., Room 1C3-2 (on the first floor), telephone (312) 567-5744 or email: disabilities@iit.edu.

Academic Honesty

It is your responsibility to be familiar with IIT's Code of Academic Honesty. The Code of Academic Honesty can be found online:
http://www.iit.edu/student_affairs/handbook/information_and_regulations/code_of_academic_honesty.shtml
You must submit your own work for homework. You are encouraged to discuss and even work with other students on homework (unless explicitly told otherwise), but material that is submitted must be your own work. For group project assignments, each group is to submit their own work. For a first violation of the IIT Code of Academic Honesty for a homework or project, the homework will receive a grade of zero for all involved students and the students will be reported to the Designated Dean for Academic Discipline (DDAD). For a first violation of the Code of Academic Honesty for a major project or an examination, the student will receive a failing grade for the course and the student will be reported to the DDAD. For a second violation, the student will receive also failing grade for the course and be reported to the DDAD.

Course Topics and Tentative Schedule

Week	Date	Lecture Topics	Reading	Assignment Due
1	Jan 13	Introduction to building enclosure design	Straube Ch. 2-3	
2	Jan 20	Building science review	Straube Ch. 4-5	
3	Jan 27	*No class – ASHRAE conference*		
4	Feb 3	Introduction to energy balances Solar radiation and enclosures	Lstiburek 2012	
5	Feb 10	Complex conduction • Thermal bridges, 2-D, and 3-D conduction		HW1
6	Feb 17	Moisture flows in building enclosures	Straube Ch. 6; Kazmierczak 2010; Karagiozis et al. 2010; Straube Ch. 9-10	HW2 (THERM)
7	Feb 24	Moisture management and control	Lstiburek 2004	
8	Mar 3	Air movements in enclosures	Straube Ch. 7; Younes et al. 2012	HW3 (WUFI)
9	Mar 10	Campus project presentations • Blower door tests in Carman Hall		Campus projects due
10	Mar 17	*No class – Spring Break*		
11	Mar 24	Windows and daylighting	Selkowitz 2011; Straube 2008	Take-home exam released
12	Mar 31	Energy simulation and enclosure design • Introduction to energy modeling software • Use of eQUEST (commercial bldg.)	Asadi et al., 2012; Asan 2006; Medina 2000; TenWolde 1997	Take-home exam due
13	Apr 7	Finish energy simulation and enclosure design • Thermal mass • BEopt and EnergyPlus (residential bldg.)		HW4 (Energy modeling)
14	Apr 14	Codes and standards		HW5 (Energy modeling)
15	Apr 21	*Guest lecture*		
16	Apr 28	Course wrap-up and future of enclosure research		
Final	May 5	No final scheduled		Final project report due

Readings

Asadi, S., Hassan, M., and Beheshti, A. Performance evaluation of an attic radiant barrier system using three-dimensional transient finite element method. *Journal of Building Physics*.

Asan, H. 2006. Numerical computation of time lags and decrement factors for different building materials. *Building and Environment* 41:615-620.

Karagiozis, A., Desjarlais, A., Kuenzel, H., and Holm, A. The Evolution of Hygrothermal Design: WUFI to WUFI-Plus. *Journal of Building Enclosure Design*, Summer 2010.

Kazmierczak, K. Using 3D thermal modeling to improve performance requirements. *Journal of Building Enclosure Design*, Summer 2010.

Liu, D-L. and Nazaroff, W.W. 2001. Modeling pollutant penetration across building envelopes. *Atmospheric Environment* 35:4451-4462.

Lstiburek, J. Built Wrong from the Start. *Fine Homebuilding* April/May 2004, pg. 52-57.

Lstiburek, J. Thermal Bridge Redux. *ASHRAE Journal*, July 2012.

Medina, M. 2000. On the performance of radiant barriers in combination with different attic insulation levels. *Energy and Buildings* 33:31-40.

Ontario Associations of Architects. *The Rain Screen Wall System*.

Selkowitz, S. High-Performance Building Enclosures: Combining View with Energy Efficiency. *Journal of Building Enclosure Design*, Summer 2011.

Stephens, B. and Siegel, J.A. 2012. Penetration of ambient submicron particles into single-family residences and associations with building characteristics. Indoor Air, doi: 10.1111/j.1600-0668.2012.00779.x.

Straube, J. and Burnett, E. 2005. *Building Science for Building Enclosures*. Building Science Press. Westford, MA. ISBN: 0-9755127-4-9.

Straube, J. 2008. Building Science Insight: Can highly glazed facades be green?

TenWolde, Anton. 1997. FPL roof temperature and moisture model: Description and verification. Res. Pap. FPL–RP–561. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 48 p.

Younes, C., Shdid, C.A., and Bitsuamlak, G. 2012. Air infiltration through building envelopes: A review. *Journal of Building Physics* 35(3):267-302.