Last updated October 22, 2013

CAE 463/524: Building Enclosure Design

Fall 2012

Illinois Institute of Technology

Department of Civil, Architectural and Environmental Engineering

3 credit hours

Course Unique Number(s)

CAE 463 Section 1: 10411 (undergraduate)
CAE 463 Section 2: 13228 (undergraduate online)
CAE 524 Section 1: 10421 (graduate)
CAE 524 Section 2: 13229 (graduate online)

Classroom and Meeting Time

Engineering 1, Room 242
Wednesdays, 5:00 PM – 7:40 PM

Course Website

http://built-envi.com/courses/cae-463524-building-enclosure-design-fall-2013/

Prerequisites

CAE 331 Building Science

Instructor

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

Office Hours

Monday and Wednesday 11:00 am to 12:00 pm and/or by appointment. You can always stop by my office Monday-Friday, but to ensure that I will be there, 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 (highly 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.

References (optional; will be given 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 hand calculations, development of spreadsheets, and/or 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 on blackboard.
- HW assignments will typically be due one week after they are assigned.
- Electronic PDF copies of HW are acceptable. The filename should be in the format of **hw1_lastname_firstname.pdf**. Other electronic formats are not acceptable.
- HW assignments should be neatly printed.
- Multipage submissions of hardcopies must have all pages stapled together.
- Students enrolled in the online course will submit HW via the Blackboard digital drop box or 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.
- Graduate students will generally be expected to perform more advanced analyses in their HW.

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 October 16, due October 23, 2013. A final exam is not currently scheduled for this course. A final report and presentation is currently scheduled to take place the last week of classes; I will also maintain the scheduled exam period (December 4, 2013) as a backup for our presentation time.

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 and final project is an individual research 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. 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	300	250	200	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 Life Sciences Room 218, 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	Aug 21	Introduction to building enclosure design	Straube Ch. 2-3	
2	Aug 28	Building science review		
3	Sep 4	Heat transfer in building enclosures • Energy balances and solar radiation	Straube Ch. 4-5	
4	Sep 11	Heat transfer in building enclosures (cont.) • Complex conduction	Lstiburek 2012	HW1
5	Sep 18	Finish complex conduction		
6	Sep 25	Moisture flows in building enclosures	Straube Ch. 6; Kazmierczak 2010; Karagiozis et al. 2010; Straube Ch. 9-10	HW2
7	Oct 2	No class - Away at conference (AAAR) **Use this time for campus building assessments**	Selkowitz 2011; Straube 2008	
8	Oct 9	Air movements in enclosures Air leakage performance testing	Straube Ch. 7; Younes et al. 2012	HW3
9	Oct 16	No class - Away at conference (ASHRAE IAQ) • Refer to posted lecture notes on a variety of applications		Take-home exam released
10	Oct 23	Moisture management and control	Lstiburek 2004	Take-home exam due
11	Oct 30	Energy simulation and enclosure design • Introduction to energy modeling software	Asadi et al., 2012; Asan 2006; Medina 2000; TenWolde 1997	
12	Nov 6	Codes and standards		HW4
13	Nov 13	Impacts of enclosures on IAQ Enclosure research	Liu and Nazaroff 2001; Stephens and Siegel 2012	Campus projects due
14	Nov 20	Final project presentations part 1 Course wrap-up		
15	Nov 27	*No class - Thanksgiving break*		
Final	Dec 4	Final project presentations part 2		Final report

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.

Contribution to Meeting Curriculum Areas (ABET)

Curriculum Area	Percentage
Basic Science & Math	
Humanities/Social Sciences	
Basic Engineering	
Introductory Architectural Engineering	20%
Professional Level Architectural Engineering	80%

Learning Outcomes and Expected Knowledge Gain: Upon completion of this course students will have proficiencies in building design as it pertains to enclosures such as walls, roof and openings. Furthermore, students will know the enclosure design requirements including those related to the heat and air flow, serviceability issues (such as building vibration and deterioration) and relevant code issues.

Performance Indicators: Performance indicators used in student learning outcomes are marked with 'X' in the following table.

Performance Indicator	Description	
I	Presentation by students (oral, poster, PowerPoint, etc.)	X
II	Term papers	X
III	Group projects (periodic progress reports project final report are required)	X
IV	Presentation by outside speakers on contemporary topics	X
V	Ethics, presentation and case study discussions	
VI	Reports (lab report, summary report on design of experiment, data analysis, research findings, etc.)	X
VII	Group discussions on understanding of profession, liabilities, professional development, etc.	
VIII	Evaluation of students' work through interviews, one-to-one meetings with students, and class discussions	X
IX	Review of learning outcomes with students and quiz on specific program learning outcomes	X
X	Overall performance in exams, homework, projects, attendance, etc.	X

Relationship of Course to ABET Outcomes

Outcome	Description	Extent of Coverage
a	Apply knowledge of math, engineering, science	3
b1	Design and conduct experiments	
b2	Analyze and interpret data	2
c	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	5
d	An ability to function on multi-disciplinary teams	1
e	An ability to identify, formulate, and solve engineering problems	4
f	A respect for, and understanding, the professional and ethical responsibility	3
g	An ability to communicate effectively	2
h	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	2
i	A recognition of the need for, and an ability to engage in life-long and continuing education	1
j	A knowledge of contemporary issues within civil engineering	3
k	An ability to use techniques, skills, and tools in engineering practice	4
l	Ability to use knowledge gained in courses in a major capstone design project	4

1 = minimum coverage in the course; 5 = major coverage in the course