New Jersey Institute of Technology Hillier College of Architecture and Design

ARCH 546 – Designing and Optimizing Building Enclosure Spring 2025, Assistant Professor Won Hee Ko, Ph.D.

Tuesdays and Friday 1PM – 2:20PM

Office hours: Fridays after class (2:30-3:30 PM). To reserve this time, please email me at <u>wonhee.ko@njit.edu</u>. If this time does not work, we can arrange a mutually convenient alternative. Office hours will be held in my office (Colton 334) or online via Zoom.

DESCRIPTION

This course explores the building envelope—the interface between a building's interior and the external environment. Students will study and design high-performance enclosures, emphasizing energy exchange, thermal dynamics, light, and occupant experience. The building envelope is a key architectural element that influences a building's aesthetic while critically impacting building performance and occupant experience. In this seminar, students will delve into envelope system design, which often receives limited focus in standard design studios. The course includes weekly lectures on various aspects of the building envelope, including climate impact, thermal comfort, daylighting and views, materials and aesthetics, structural systems and fabrication. Tutorials on relevant building simulation tools, such as ClimateStudio, Grasshopper-Ladybug, Clima Tools, are also provided. In the latter part of the semester, students will work on a small building envelope design project that considers environmental impact, facade geometry, and material properties, alongside occupant experience. Through project-based learning, students will gain practical skills in facade design, assembly, and material selection with an emphasis on optimizing building performance and indoor environmental quality. In this course, students will develop a critical understanding of performance challenges in facade design, learning to integrate energy optimization strategies for occupant well-being. Proficiency with Rhinoceros 3D is required, and prior experience with Grasshopper is recommended.



COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

- Research and analyze architectural precedents and then apply their lessons to facade design projects, applying relevant insights to facade design projects.
- Understand how facade design strategies can mitigate external environmental conditions.
- Develop facade design solutions that address challenges related to energy efficiency, occupant experience, and overall building performance.
- Select and apply appropriate building performance metrics and tools to inform and support design decisions.
- Integrate various design constraints to create functional and innovative facade solutions.
- Demonstrate familiarity with the fundamentals of building envelopes, material properties, and passive building strategies.

REQUIRED MATERIALS AND RESOURCES

Students are required to have a Windows-based laptop with the following software installed:

- **Rhinoceros**® (version 6 or higher)
- **ClimateStudio** (for daylighting and energy simulations)
- Grasshopper with Ladybug Tools (for solar geometry and shading mask analysis)

The course relies on ClimateStudio, a Rhino® plug-in for daylighting and energy analysis based on Radiance, DAYSIM, and EnergyPlus. ClimateStudio is available through Solemma LLC (<u>https://www.solemma.com/climatestudio</u>) with an educational license key will be made available. The ClimateStudio User Guide (https://climatestudiodocs.com/) is a required resource for learning the software. Students are responsible for reviewing the tutorials to successfully complete course assignments and projects.

Grasshopper with Ladybug Tools, a Rhino® plug-in for parametric environmental analysis, is available for free through the food4Rhino website (<u>https://www.food4rhino.com/en/app/ladybug-tools</u>). This course will utilize specific functions of Ladybug Tools to generate sun-path diagrams, shading need diagrams, and shading masks. While Grasshopper and Ladybug Tools can have a steep learning curve, the instructor will provide a template that allows students to plug their geometry into Rhino and run basic analyses. These analyses will be essential for understanding key concepts that help optimize facade performance. The skills developed will form the foundational knowledge needed for successfully designing and optimizing building enclosure systems.

ASSIGNMENTS

There are ten assignments designed to help students integrate performance-based design concepts into their course projects. All completed assignments must be submitted as a single PDF file on Canvas by the specified due dates (e.g., 12:00 PM on Friday). Direct email submissions will not be accepted. Ensure that your file is readable and free of errors—corrupt or illegible files will result in a failing grade for the assignment. Collaboration for discussion and better understanding is encouraged, but each student must submit their own work. Each simulation result should be accompanied by a clear, concise explanation. Throughout the

semester, students will give brief progress presentations. The instructor will provide feedback to be incorporated into final presentations at the end of the term.

GRADE DEFINITIONS AND ASSIGNMENTS

<u>https://catalog.njit.edu/undergraduate/academic-policies-procedures/</u> Students are required to follow the course schedule and present their work on time. This applies to all assignments and presentation material as scheduled and requested by their instructor. A student may request an individual change to the due date for extenuating circumstances only via email and approved in writing by the studio instructor. Not presenting work at the required time will result in a non-passing grade for that exercise.

The final grade for the course will be based on four components. Students are also expected to actively participate in discussions during lectures and presentations. The final grade follows a cumulative grading system, with each exercise contributing a specific percentage to the overall course grade:

| Part 1 | Precedent studies | | | | |
|--------|---|------|--|--|--|
| | • Research (Assignment 1A) | 5% | | | |
| | • Geometry building (Assignment 1B) | 5% | | | |
| Part 2 | Environmental analysis | | | | |
| | • Climate analysis (Assignment 2) | 5% | | | |
| | • Shading needs diagram and mask (Assignment 3) | 5% | | | |
| | • Illuminance analysis (Assignment 4) | 5% | | | |
| | • Glare and view analysis (Assignment 5) | 5% | | | |
| | • Thermal analysis (Assignment 6) | 5% | | | |
| Part 3 | Design project | | | | |
| | Midterm presentation: hypothesis (Assignment 7) | 15 % | | | |
| | Final presentation: proposal (Assignment 8) | 35 % | | | |
| Part 4 | Report | | | | |
| | Guest lecture summary (Assignment 9) | 10 % | | | |
| | Final Booklet (Assignment 10) | 5 % | | | |
| | | 100% | | | |

*Actively engaged discussion expectations:

- Be prepared
- Ask questions
- Listen to others
- Be focused without personal distractions

RECOMMENDED READINGS

Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer: Facades: principles of construction, 2007

https://primo.njit.edu/permalink/01NJIT_INST/32cv1j/alma994913233105196

Knaack, Ulrich, Koenders, Eddie, Alexandrakis, Elena: Building Physics of the envelope: 2018 https://primo.njit.edu/permalink/01NJIT_INST/1ci1d95/alma995067755805196 Aksamija, Ajla: Sustainable facades design methods for high-performance building envelopes, 2013

https://primo.njit.edu/permalink/01NJIT_INST/32cv1j/alma994914636405196

Herzog, Thomas; Krippner, Roland.; Lang, Werner.; McKenna, Christina: Facade construction manual, 2017

<u>https://primo.njit.edu/permalink/01NJIT_INST/1ci1d95/alma994841563405196</u> Deplazes, Andrea, 2005: Constructing architecture : materials, processes, structures, a handbook. Birkhäuser.

https://primo.njit.edu/permalink/01NJIT_INST/32cv1j/alma991295723405196

Herrmann, Eva Maria, Krammer, Martin, Sturm, Jörg, Wartzeck, Susanne, Reichel: Enclose / Build: walls, façade, roof

<u>https://primo.njit.edu/permalink/01NJIT_INST/32cv1j/alma992784283405196</u> Heschong, Lisa: Visual delight in architecture: daylight, vision and view

https://primo.njit.edu/permalink/01NJIT_INST/32cv1j/alma995213343105196

Browning, William D.: Nature Inside: A biophilic design guide https://primo.njit.edu/permalink/01NJIT_INST/32cv1j/alma995189847905196

LEARNING AND TEACHING CULTURE POLICY

In addition to the overarching values and ethics of the university, the New Jersey School of Architecture (NJSoA) is dedicated to optimism, diversity and solidarity, professional conduct, constructive evaluation and instruction, collaborative community, health and wellbeing, time management and school-life-work balance, respectful stewardship and space management, and well-rounded enrichment. The pedagogy of architecture and design is as complex as it is rewarding, and as dynamically evolving as the people who learn and teach it. This understanding resides at the core of the NJIT Learning and Teaching Culture

Policy: https://design.njit.edu/learning-and-teaching-culture-policy

ACADEMIC INTEGRITY / PLAGIARISM

The NJSOA maintains that academic integrity and honesty are of paramount importance. Cheating and plagiarism will not be tolerated. The NJIT Honor Code will be upheld, and any violations will be dealt with by the department or brought to the immediate attention of the Dean of Students. All students are responsible for upholding the integrity of NJIT by reporting any violation of academic integrity. The identity of the student filing the report will remain anonymous. All students are expected to adhere to the University Code on Academic Integrity: <u>https://www.njit.edu/dos/academic-integrity</u> **and to the Code of Student Conduct:** <u>https://www.njit.edu/dos/sites/njit.edu.dos/files/NJIT%20CODE%20OF%20CONDUCT%20AY</u> <u>2425.pdf</u>

Please note that it is the faculty's professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu and reference the sites below: https://www.njit.edu/dos/academic-integrity,

https://www.njit.edu/dos/code-student-conduct-article-11-university-policy-academic-integrity

HCAD librarian Maya Gervits has assembled excellent resources for a students use on using images, citing, and plagiarism: <u>https://researchguides.njit.edu/c.php?g=671665&p=4727920</u>

NAAB SHARED VALUES OF THE DISCIPLINE AND THE PROFESSION

The National Architectural Accrediting Board accredits NJIT's architecture program. The NAAB has Shared Values of the Discipline and the Profession that must be covered by any architectural curriculum to attain their approval. This course satisfies the following shared values:

Design: Architects design better, safer, more equitable, resilient, and sustainable built environments. Design thinking and integrated design solutions are hallmarks of architecture education, the discipline, and the profession.

Environmental Stewardship and Professional Responsibility: Architects are responsible for the impact of their work on the natural world and on public health, safety, and welfare. As professionals and designers of the built environment, we embrace these responsibilities and act ethically to accomplish them.

Leadership, Collaboration, and Community Engagement: Architects practice design as a collaborative, inclusive, creative, and empathetic enterprise with other disciplines, the communities we serve, and the clients for whom we work.

ATTENDANCE POLICIES

Our course consists of lectures, tutorial sessions, group-discussions, presentations, and desk crits in our class room. It is mandatory for students to attend the **entire** class period (Tuesdays and Fridays, 1:00-2:20 PM).

Excused Absences: Are for medical and religious reasons or pre-approved for student-athletes only. An absence due to illness can be excused if the student has filed official documentation (licensed medical practitioner including NJIT Health Services) with the Office of the Dean of Students. The Office of the Dean of Students will, in turn, notify the instructor(s) that appropriate documentation has been received and confirmed, and detail what accommodation is warranted. These accommodations may range from identified dates for excused absences (normally for temporary illness) to extra time for projects and assignments (for ongoing medical issues).

Contact Dean of Students: http://www.njit.edu/doss/

<u>Unexcused Absences:</u> Students will be counted **absent if they are not in class 15 minutes after the scheduled start time**. If a student will be late or absent for any reason it is their responsibility to notify their instructor before missing class and provide sufficient cause for nonattendance to maintain grades. Notification can be made by email. **Students will be penalized half a grade (from an A to B+) for each absence after three unexcused absences.** The instructor is under no obligation to repeat any missed information or provide access to lecture notes or presentation materials to students who arrive late. Yet it remains the responsibility of the student to learn the material presented.

OTHER POLICIES AND EXPECTATIONS

Late submission: Students are required to submit all assignments on time regardless of class attendance by the announced due dates via Canvas. Late submission will be penalized. Students may be allowed to make up missed work with an excused reason depending on the nature of extenuating circumstances that shall be certified by the Dean of Students as described above for Attendance.

Kepler/Canvas: Students are required to post their graded work on Kepler in a timely manner. All files must be resized and renamed and saved as jpg. Images must retain their original proportions without being enlarged. All files must be 260dpi and a minimum of 11"/17" horizontal or vertical. The filename should be saved according to the following naming convention: **<Last name_First name_Assignment #_Date YYYYMMDD.>** Please check the legibility of each .pdf file after saving. Students will not receive their final grade until posting all required Kepler files, according to the instructor's directions. Failure to follow the instructions on Kepler/Canvas posting will result in a deduction of a grade (from an A to B).

<u>Communication during the Semester:</u> In addition to in-class announcements, the instructor will use Canvas or email to post materials for the course. Email communication with students will be made by NJIT email (<u>wonhee.ko@njit.edu</u>) only. Do NOT email through Canvas. Please check your NJIT email prior to each class for possible information pertaining to class. It is your responsibility to maintain your NJIT email account in working order and check it regularly.

<u>Cell Phones and Other Electronic Devices:</u> Out of respect for the course instructor and other students, please turn off cell phones or any electronic devices which may interfere with class instruction. Laptop computers are allowed to be used only for the software tutorial sessions. Students who are observed using cell phones or other electronic devices for text messaging or any other non-class activity during class time will receive a 5% reduction of the student's final semester grade for each incident. Cell phones and other electronic devices are not to be used to record class content in any manner.

<u>Recording of Classes:</u> Students are not allowed to record the class sessions in any manner without the permission of the course instructor.

<u>Subject to Changes</u>: Because the nature of design and design instruction, as well as simulation tools can be unpredictable, assignments or day to day activities are subject to change with advance notice, as deemed appropriate by the instructor. Policies and major deadlines will not change.

SCHEDULE

Check <u>https://www5.njit.edu/registrar/calendars/</u> for the University schedule.

Meeting-by-meeting schedule is attached to the following page.

| Week | Date | Topics | In-class activities | Assignments - intro | Assignments - due | Laptop required |
|------|------|--------------------------------------|---|---------------------|---------------------|-----------------|
| 1 | 1/21 | Introduction | Intro; Survey | | | |
| | 1/24 | Case study selection | Group formation, facade book review; case study selection | 1A Introduction | | |
| 2 | 1/28 | Architecture and facades | Lecture | | | |
| | 1/31 | Case study presentations | 5 min. each; modeling tips | 1B Introduction | 1A Presentation | Х |
| 3 | 2/4 | Climate and facades | Lecture | | | |
| | 2/7 | Climate analysis | Clima tools, ClimateStudo (CS) | 2 Introduction | 1B Submission | Х |
| 4 | 2/11 | Solar geometry and facades | Lecture | | | |
| | 2/14 | Shading needs diagram, shading mask | Ladybug tools - shading mask | 3 Introduction | 2 Submission | Х |
| 5 | 2/18 | Daylight and facades | Lecture | | | |
| | 2/21 | Daylight analysis | CS- Illuminance, UDI, sDA, ASE | 4 Introduction | 3 Submission | Х |
| 6 | 2/25 | Guest lecture (Facade consulting) | Lecture | | | |
| | 2/28 | View and facades | Lecture | 5 Introduction | 4 Submission | Х |
| 7 | 3/4 | Visual comfort and view analysis | Google earth studio, CS- glare analysis (DGP) | | | |
| | 3/7 | Thermal comfort, energy and facades | Lecture | | | |
| 8 | 3/11 | Thermal and energy analysis | CS - thermal analysis: UDI, CO2 emission | 6 Introduction | 5 Submission | Х |
| | 3/14 | Materials and facades | Lecture | 7 Introduction | | |
| 9 | 3/18 | No class - Spring break | | | | |
| | 3/21 | No class - Spring break | | | | |
| 10 | 3/25 | Guest lecture (Facade designer) | Lecture | | 6 Submission | |
| | 3/28 | Desk crits - design project | Group work | | | Х |
| 11 | 4/1 | Midterm Presentation | Design project - overview, hypothesis | | 7 Presentation | |
| | 4/4 | No class (ARCC Conference) | | | | |
| 12 | 4/8 | Structure, detail and facades | Lecture | | | |
| | 4/11 | Guest lecture (Facade engineering) | Lecture | | | |
| 13 | 4/15 | Guest lecture (Facade manufacturing) | Lecture | | | |
| | 4/18 | No class - Good Friday | | | 8 Guest Lecture Sur | nmaries |
| 14 | 4/22 | Desk crits - design project | Group work - analysis | | | Х |
| | 4/25 | Desk crits - design project | Group work - analysis | | | Х |
| 15 | 4/29 | Desk crits - design project | Prep for the final presentation | | | Х |
| | 5/2 | Final presentation | Design project - proposal | | 9 Presentation | |
| | 5/17 | Final booklet due | | | 10 Final Booklet | |

Meeting-by-meeting Schedule (DRAFT as of January 21, 2025: Subject to Revision Following Student Discussion)