Mary Guzowski, Loren Abraham, and Ian McLellan

School of Architecture, University of Minnesota

Carbon Neutral Design Module

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE-Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

A perennial challenge for ecological design education in schools of architecture has been the failure to integrate environmental technology courses and design studios. Despite the magnitude of ecological challenges and the complexity of integrated zero-energy carbon-neutral design education, many students are provided little or no formal education on the topic. To create a model of integrated ecological design education, the School of Architecture at the University of Minnesota recently eliminated the required environmental technology courses in the professional graduate architecture program and replaced them with a new studio/technology hybrid course focusing on the integration of luminous and thermal design for zero-energy and carbon-neutral architecture in the first year (second semester) of the three-year graduate program. The intention is to introduce ecological design principles and methods as early as possible in order to inform and support the long-term sustainable design education of the students. An ecological approach to cold-climate passive heating, natural ventilation, and daylighting were at the core of the new design curriculum, into which innovative systems and renewable energy were integrated. Design excellence, comfort, and human experience were given equal importance as were energy and ecological performance.

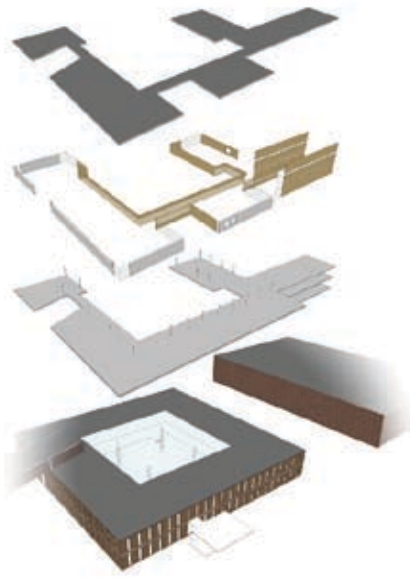
PROGRAM STATEMENT

The students were asked to consider how architectural design can respond to the growing challenges of global warming and climate change. While there are many issues related to zero-energy and carbon-neutral design, the new course focused on daylighting, thermal, and bioclimatic considerations for cold climate architectural design along with reductions in fossil fuel consumption and greenhouse gas emissions. The course project was a new "Minnesota Zero-Emission/Zero-Energy Design Lab" in a proposed third floor addition to Rapson Hall for the College of Design at the University of Minnesota (a real project proposed by the Dean Thomas Fisher).

OBJECTIVES

The objectives for the course were to: 1) remedy the separation between environmental technology course content and the design studio, 2) introduce ecological processes, methods, and tools for architectural design, and 3) prepare students to integrate zero-energy and carbon-neutral strategies and assessment methods into their future design education and practice. The vehicle for the course investigation was a local project, which was the design of a new "Zero-Emission/ Zero-Energy Design Lab" as a proposed third floor addition to the College of Design at the University of Minnesota (a real project proposed by the Dean of the College). The course challenged the notion that zero-energy and carbon-neutral design was mainly a technological problem. Students were asked to investigate how the building – through its site design, massing, section, envelope, materials, systems integration, and details – could significantly harvest solar and renewable energy to reduce and meet the energy demands while also addressing design excellence and creating meaningful architectural experiences.

The design method was to consider a "hybrid-solar approach" to zero-energy carbon-neutral design which integrated both architectural and technological issues. Solar design and renewable energy were at the heart of the problem. Consideration of solar and renewable energy as both design and technological issues were addressed by concurrently integrating the issues at different scales and levels of design detail. The educational challenge was to design a curriculum that captured the complex design processes, methods, and integrated thinking necessary to promote the next generation of zero-energy and carbon-neutral sustainable design practice.



Envelope Analysis

Diedrich, Erickson, and Thompson

Computer study of the envelope solar control.

Studio Teaching Topic KEY

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TEACHING TOPICS PROFILED

1. Site & Bioclimatic Design: Between Earth & Sky

Produce a written program document with a problem statement and statement of intent, a written and graphic site analysis/interpretation, and an analysis of appropriate precedents... Develop an understanding of the relationship between the building program and the site that would serve to facilitate the realization of the designer's intentions as the design process unfolded.

2. Lightscapes 1: Light in Place & Time

Develop an understanding of the relationship between the building program and the site that would serve to facilitate the realization of the designer's intentions as the design process unfolded.

3. Optimizing Building Performance & Thermal Loads

The investigation of relationship between possible design strategies and the climate and microclimate, and the quantitative physical properties of the site.

4. Ecological Envelopes: Fivefold Functionality

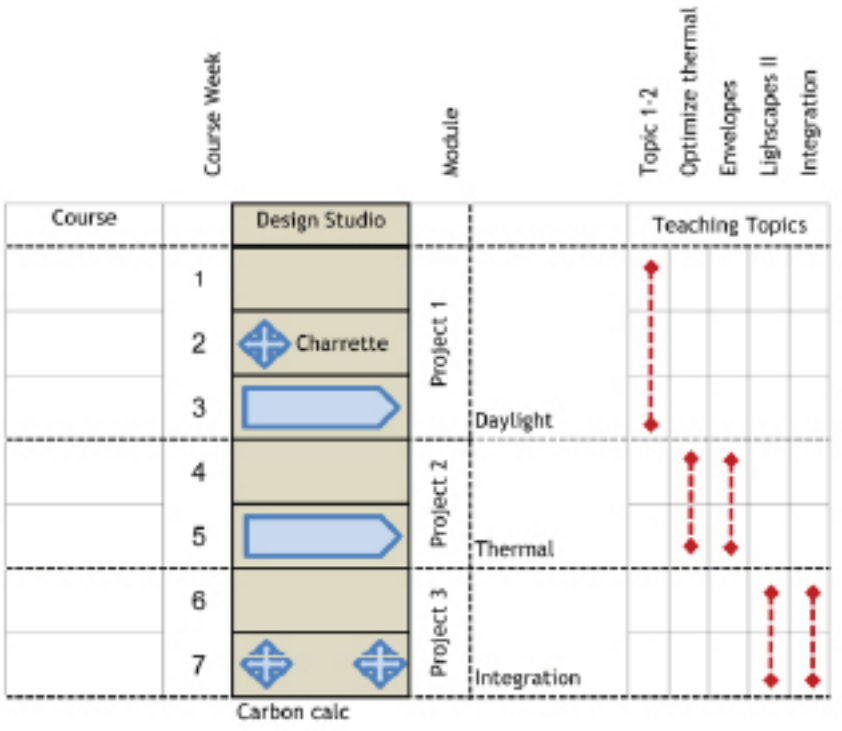
The investigation of relationship between possible design strategies and the climate and microclimate, and the quantitative physical properties of the site.

5. Lightscapes II: Experiencing Sustainability

LEED checklist and descriptions of individual credits, "GreenBuilding Suite", etc.

6. Whole Building Integration

Use the LEED checklist and the eQuest computer program to monitor building performance throughout the schematic design phase.



Philosophy of CND Studio Instruction

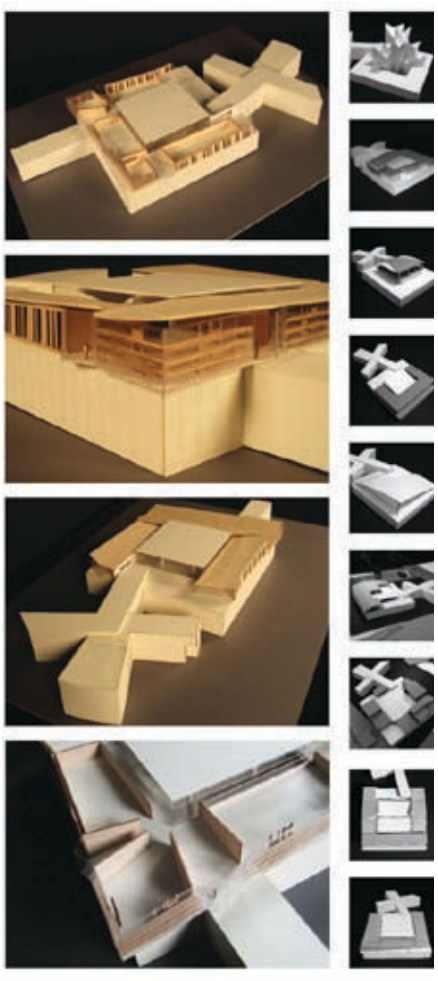
Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULELuminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

The team of instructors needed to carefully consider how the course structure and content could support the primary objectives of the course (please see previous page). While tangible design strategies, processes, methods, and tools were key to the successfully meeting the ecological objectives, a perhaps greater concern was to model an ecological process for design thinking that would inform the students' future education and practice. Dr. David Orr, professor of environmental studies at Oberlin College, argues that humans – not design or technology – are the challenge to implementing a lasting and ecological transformation of design: "The greatest impediment to an ecological design revolution is not, however, technological or scientific, but rather human…A real design revolution will have to transform human intentions and the larger political, economic, and institutional structure that permitted ecological degradation in the first place…[1]" The team of instructors was interested in fostering an ecological mode of design thinking and providing processes and methods which would enable the students to explore the complexity of the ecological design issues and intentions.

In contrast to the typical design studio, this new nine-credit hybrid design/technology studio was scheduled for only 6.5 weeks (in contrast to 15 weeks). The forty-five students worked in teams of three and took only one additional three-credit course during the 6.5 week period. Class met from 10:00 a.m. to 6:00 p.m. on Mondays, Wednesdays, and Fridays. Morning sessions were organized with lectures, while afternoon sessions were typically used to meet with teams in the design studio, to study local buildings, and to teach the computer tutorials for Ecotect and other performance methods and tools. As we find in professional practice, each student team was responsible for integrating all of the course content and methods into the design project; however, individual student were not expected to be responsible for all of the content (e.g. one student might focus on the daylighting modelling while another integrated the daylighting into a thermal assessment). To ensure that all students learned the essential assessment and analytical methods, the completion of computer tutorials were required of each student. The course was taught by a team of design educators in collaboration with visiting practitioners (including three fulltime educators in environmental technology, sustainable design, and computer methods; three visiting design critics who provided additional design studio reviews; and three visiting practitioners who attended the reviews).

The content of the course was organized as a series of iterative projects around six topical modules related to zero-energy carbon-neutral design: 1) bioclimatic response, 2) daylighting inspiration, 3) thermal exploration, 4) ecological envelope, 5) experiencing sustainability, and 6) an integrated whole. While the projects were designed to encourage students to consider multiple issues concurrently, the emphasis of the projects shifted between focused investigation of an individual topic to integration across topics. Students addressed the design of the "whole" and the design of the "parts" by alternately focusing on different issues and scales. The following discussion considers the educational intentions, processes, and outcomes of the modules and how they were integrated throughout the 6.5 week period.



Site Massing Analysis
Egon, LaVenture, and Tanaka

Physical study models of daylighting and thermal opportunities and the site and massing scales.

Philosophy of CND Studio Instruction (cont.)

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University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULELuminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

AN INTEGRATED WHOLE

The series of projects and iterative invcestigagtions focused on the integration of architectural design and lighting, thermal, and renewable energy systems. Emphasis was on the creation of a meaningful whole that supported human experience, comfort, ecological performance, and design excellence. At the end of the 6.5 week period, teams presented a "final" iteration of the project to illustrate the evolution of their design thinking and how qualitative and quantitative evaluation informed their design thinking. They developed an integrated design solution for the proposed building addition and compared the performance to a "baseline case," which was their initial concept presented in Project One and analyzed throughout the preceding projects. Teams were required to meet the daylighting, thermal, ventilation, energy, greenhouse gas emissions, and other relevant design and ecological goals set by the team. They analyzed the final design and compared the results to the original "baseline case" showing the estimated improvements in energy use, carbon dioxide emissions, thermal comfort, daylighting performance, life-cycle cost and other ecological metrics of the student's choice.

The evaluative process for the course included extensive use of physical models (massing, section, envelope models, room studies); annotated wall sections; daylighting studies (qualitative time sequence photographs of physical models and Ecotect, DAYSIM, and/or Radiance quantitative analysis on diurnal and seasonal basis); Ecotect Studies for the thermal performance for passive solar and system integration; carbon calculations related to lighting and heating; integration drawings and diagrams; and written findings and conclusions on architectural design and systems integration.

ACKNOWLEDGMENTS

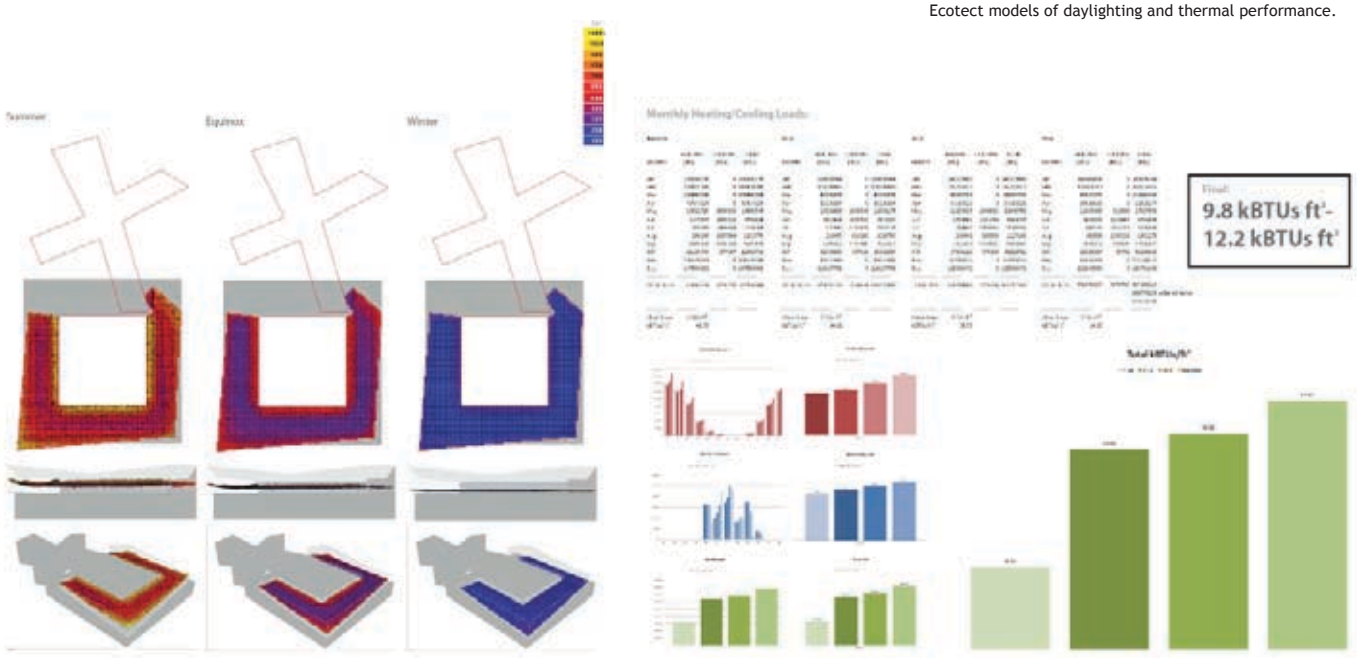
The instructors gratefully acknowledge the contributions to this design studio by the first year graduates students from Spring 2008; the teaching assistants; the visiting design critics; the visiting professional critics; and the Center for Teaching and Learning Services at the University of Minnesota.

Visiting Design Critics:
Renee Cheng, Professor and Head; Benjamin Ibarra, Assistant Professor; Sharon Roe, Adjunct Associate Professor
Visiting Professional Critics:
Nina Ebbighausen, HGA; Doug Pierce, Perkins+Will; Jennifer Yoos, VJAA
Center for Teaching and Learning Services:
Dr. Ilene Alexander

[1] David Orr, The Nature of Design (Oxford: Oxford University Press, 2002), p. 23-24.

Luminous and Thermal Analyses
Egon, LaVenture, and Tanaka

Ecotect models of daylighting and thermal performance.



Supporting Material

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Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

COURSE MATERIALS

Guzowski et al., ARCH 5516 Syllabus 2008, PDF.
Guzowski et al., ARCH 5516 Project Statements 2008, PDFs.

SUGGESTED TEXT

Kwok, Alison and Walter Grondzik. The Green Studio Handbook. London: Architectural Press, 2007.
Lechner, Norbert. Heating, Cooling, Lighting: Design Methods for Architects, New York, Wiley, 2001.

REQUIRED SOFTWARE

ECOTECT version 5.50; DAYSIM, and Radiance

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- Deutsches Architektur Museum, editor. The Secret of the Shadow: Light and Shadow in Architecture. Germany: DAM, 2002.
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- Guzowski, Mary. Daylighting for Sustainable Design. New York: McGraw-Hill, 2000.
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ENVELOPE DESIGN (Daylight and Thermal Issues)

- Balkow et al. Glass Construction Manual, Boston: Birkhäuser, 1999.
- Compagno, Andrea. Intelligente Glasfassaden : Material, Anwendung, Gestaltung : Intelligent Glass Facades: Material, Practice, Design. Boston : Birkhauser-Verlag, 2002.
- Schittich, Christian, editor. Building Skins. Basel: Birkhäuser Publishers, 2001.
- Schittich, Staib, Balkow, Schuler, and Sobek. Glass Construction Manual. Basel: Birkhäuser Publishers, 1999.
- Wigginton, Michael and Jude Harris. Intelligent Skins, Oxford: Butterworth-Heinemann, 2002.

THERMAL AND SYSTEMS DESIGN

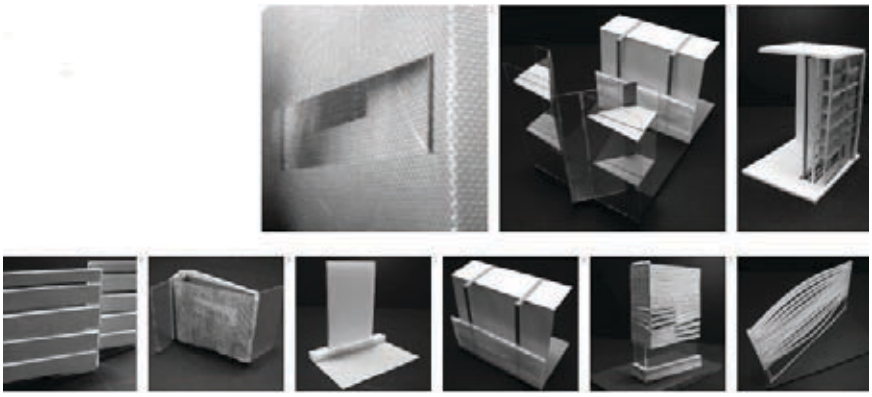
- Abraham, Loren E. (adaptation) and Thomas Schmitz-Gunther, editor. Living Spaces: Ecological Building and Design Cologne, Germany : Konemann Verlag., 1999.
- Allen, Edward. Fundamentals of Building Construction; 3rd ed.; New York : Wiley, 1999.
- Brand, Stewart; How Buildings Learn: what happens after they're built, New York, NY : Viking, 1994.
- Brown, G.Z., Mark DeKay. Sun, Wind & Light; 2nd ed., New York : J. Wiley, 2001.
- Mazria, E. The Passive Solar Energy Book. expanded professional edition. Emmaus, PA, Rodale Press, 1979.
- Stein, B., J. Reynolds, W. Grondzik, and A. Kwok. Mechanical and Electrical Equipment for Buildings, 10th Ed., Wiley, 2006.

RELATED PAPER

Guzowski, M. with L. Abraham, Integrated Luminous and Thermal Design: A Cold Climate Approach to Zero-Energy Carbon-Neutral Design Education, 26th Conference on Passive and Low Energy Architecture, Quebec, Canada, 2009; PDF.

Envelope Studies
Egon, LaVenture, and Tanaka

Physical study models of daylighting and thermal opportunities and the envelope scale.



10 Critical Issues / 10 Common Mistakes

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral

7 critical issues in THE teaching of Carbon Neutral Design

This model of integrated ecological design education succeeded in helping students to meaningfully integrate zero-energy and carbon-neutral design thinking into their personal design and decision-making processes. The instructors witnessed a profound change over the course of the 6.5 weeks in the students' abilities, confidence, and skill in framing design questions and then investigating and weighing both poetic and pragmatic ecological design considerations. The instructors hope that this studio has laid a solid foundation that will positively support the students' ability to address ecological design in their future education and practice. The experimental course will continue to evolve and change as we test and develop the new curriculum over the coming years. Lessons for design educators include:

1. *Dissolve the Boundaries between Technology and Design: This hybrid design/technology studio is but one way to bridge the gap between the technical courses and the design studio. Other innovative models are being explored in design programs throughout the world. Even if it is not possible to make significant curricular changes, find creative ways to integrate the design and technology courses.*
2. *Promote Integrated and Iterative Design Thinking: The greatest benefit from the design/technology hybrid course was the growth and change that was evident in the students' ability to frame critical design questions and to address these questions with a high degree of skill and confidence. The studio also provided the depth to meaningfully apply qualitative and quantitative assessment methods. Iterative and integrative processes were essential in moving design thinking to a deeper level.*
3. *Prioritize Passive Design: Cold climate passive strategies for daylighting, passive heating, and natural ventilation were the foundation of the course. Passive design was considered a primary means to meet energy demand for lighting, heating, and cooling. Innovative approaches to building materials, envelope, and renewable energy systems must be integrated with passive design strategies.*
4. *Explore Qualitative and Quantitative Assessment Methods: The course emphasized the importance of both qualitative and quantitative design tools as means to develop and assess the architectural quality and performance. This included varied scales of physical models (e.g. massing models, ½" envelope details, and ½" daylighting and section models). Other methods of assessment included sketching, diagramming, Ecotect studies for daylighting and thermal performance, and carbon calculations. Ecotect was a valuable tool for early design studies (even in the first week of class), as it is fairly easy to learn and quickly enables students to compare and contrast the luminous and thermal implications of decisions related to massing, section, form, and window design. Qualitative daylighting models and sketching were used both early in the design process and toward the end of the investigation as a complement to the Ecotect studies.*
5. *Promote Meaningful Collaboration: Collaborative teaching and learning was essential, for no faculty or student can be an expert in all aspects of ecological design. A team of instructors, visiting critics, and professionals was essential in providing the necessary expertise. Students gained valuable experience collaborating and sharing responsibilities.*
6. *Acknowledge the Heightened Intensity: Although successfully condensing the content into half of a typical semester (6.5 weeks) seemed highly challenging, it successfully focused the students' attention. With only one additional class, students were less distracted by competing interests and seemed to work more effectively and purposefully toward a successful end result. The disadvantage of the condensed schedule was the limited time to process and synthesize the design methods and evaluative tools. Despite this limitation, the intensity of the course fostered a spirit of collaboration and exploration that will serve the students well as they move forward with their future ecological design education and practice.*
7. *Start Early: Introduce issues of zero-energy and carbon-neutral design in the first year of the graduate program. This provides an ecological foundation and qualitative and quantitative approaches to sustainable design which can inform the following years of design education and practice.*

5 student design mistakes that undermine the goal of Carbon Neutral Design

1. *Non-Iterative Design Process: Students are unlikely to reach zero- and carbon-neutral goals if they do not use an iterative and integrative design process. Carbon-neutral and zero-energy design requires iterative investigations which systematically considers diverse layers of design issues across different topical concerns and scales. Students need to be provided clear processes and methods to integrate the complexity of issues and design integration.*
2. *Unwillingness to Integrate Passive Solar Design: Unless passive strategies are included, it will be impossible to meet zero- and carbon-neutral goals. It is the responsibility of the instructor to provide real design principles, methods, and tools to assess and refine passive solar strategies (including daylighting, natural ventilation, and passive heating).*
3. *Considering Form as Independent of Ecological Goals and Intentions: Students are unlikely to meet zero- and carbon-neutral goals if they approach the building form (massing, plan, and section) as independent of ecological concerns for natural lighting, ventilation, and heating.*
4. *Unwillingness to Use Qualitative and Quantitative Design Tools: Students will be unlikely to integrate both ecological performance and design excellence unless they are willing to combine both quantitative assessments for comfort and performance with qualitative and experientially-based design tools.*
5. *Disbelief that Design Matters in Terms of Ecological Impact: Students will be unlikely to meet zero- and carbon-neutral goals if they are uninterested and do not believe that design choices at every scale can have a profound ecological impact.*

Site and Bioclimatic Design: Between Earth and Sky

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

Design/Performance Objective

- Explore site and bioclimatic forces as they influence daylighting, thermal, and architectural design.
- Investigate poetic and pragmatic daylighting and thermal design opportunities and considerations related to site, bioclimatic, and ecological forces.
- Consider the architectural and environmental implications of site, climate, and place.
- Investigate processes and tools for site and bioclimatic analysis and design.

Investigative Strategy

In Project One, students participated in a design charette to evaluate Rapson Hall at the site and building scales and develop preliminary design proposals that explored the bioclimatic "story" or "narrative" of their site and program for the "Minnesota Zero-Emission/Zero-Energy Design Lab" at the College of Design. They were asked to develop a graphic and verbal presentation capturing the experiential and physical forces on the site that could shape architectural design from a bioclimatic perspective. Phase One focused on an ecological inventory and in Phase Two they were asked to develop three design proposals at the scales of the site and building massing.

Evaluation Process

Phase One: Bioclimatic Inventory (photography, graphics, diagrams):

- Site and bioclimatic forces and features
- Site and luminous and thermal phenomena
- Indoor environmental quality assessment
- Site/building journey
- Construction & enclosure
- Experiential and poetic opportunities

Phase Two: Concept Proposals (physical and computer models at the site and massing scales)

- Physical concept models at 1/32"
- Graphic presentation for each 1/16" proposal
- Time sequence studies of models
- Ecotect solar studies at the site/ building massing scale
- Written and graphic critique on critical bioclimatic issues and lessons

Bioclimatic Analysis
Holler, Portilla, and Tupy

Bioclimatic study of region and site ecology, solar access, and windflow. Contextual study to inform design thinking for daylighting and thermal design at the site and massing scales.

Site and Bioclimatic Design: Between Earth and Sky (cont.)

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Evaluative Criteria

- Clarity and craft of "Site & Bioclimatic Analysis"
- Overall craft of presentation boards and drawings
- Clarity, craft, and execution of design intentions demonstrated in the models and drawings

Cautions- Possible Confusions

Emphasize the exploratory intention of the project (getting to experience and understand the bioclimatic aspects of a "real place" through first hand observation (qualitative and quantitative). The charette is intended to quickly open diverse design possibilities rather than solutions.

Duration of Exercise

Four day design charette (assigned on Friday and due on Monday).

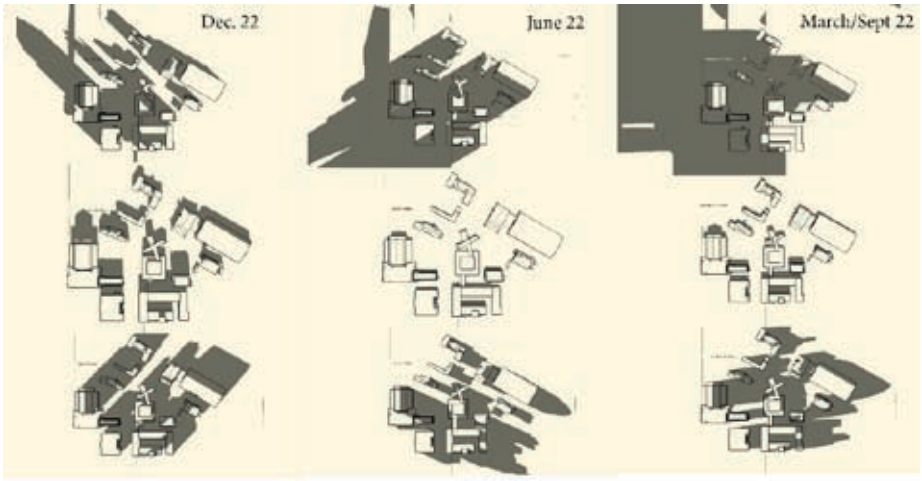
Degree of Difficulty

Introductory level for first year graduate students.

References

ELECTRONIC READING:
Knowles, Ralph. Ritual House, Washington: Island Press, 2006, pp. 3-73 (Chapters on Sheltering, Migration, Transformation, and Metabolism).

REFERENCE BOOKS ON RESERVE: See list in bibliography.



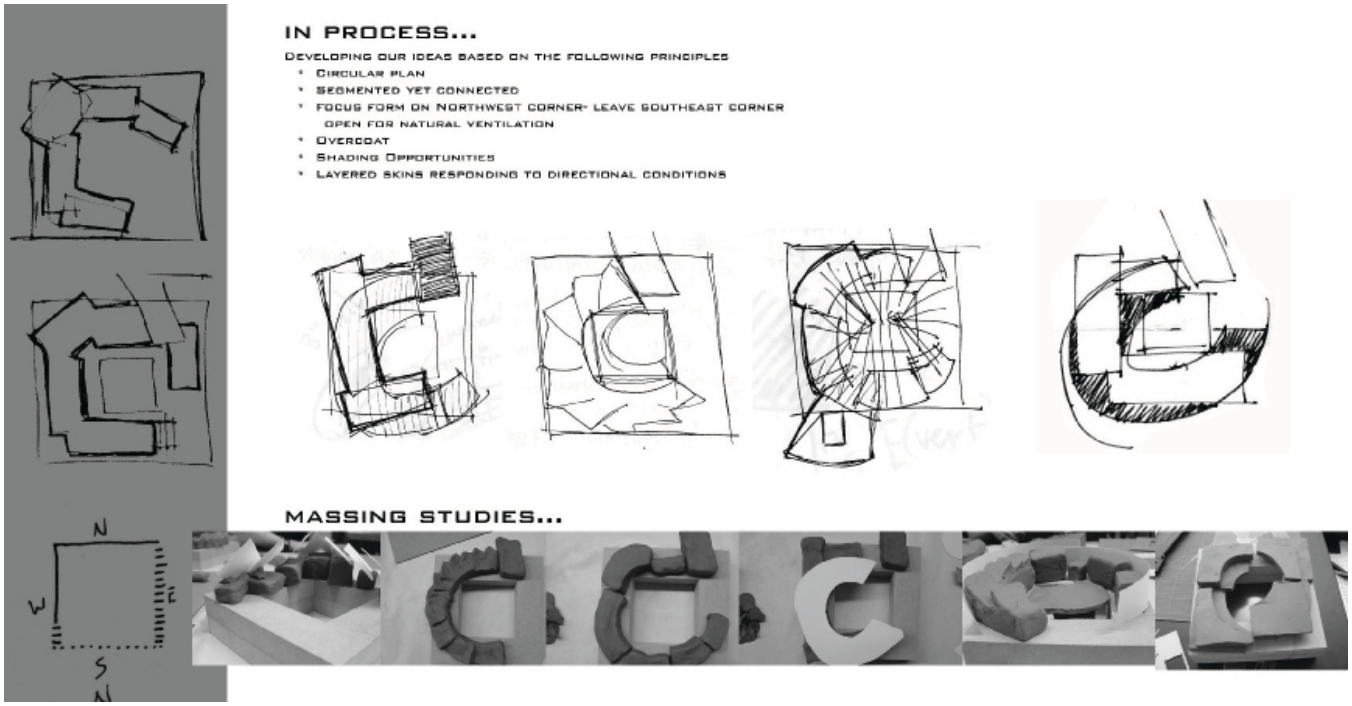
Bioclimatic Analysis
Garman, Leaf, and Nicklay

Bioclimatic consideration of ecological scales. Contextual study to inform design thinking for daylighting and thermal design at the site and massing scales.

Lightscapes I: Light in Place & Time

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design



Design/Performance Objective

- To explore how architecture can capture and celebrate an experience of "light in place and time".
- To both connect to place and to harvest free energy from the sun and wind.

Investigative Strategy

In Project Two, students worked as a team to evaluate the daylighting design from their bioclimatic design proposals in Project One. They are asked to reconsider their project proposals in ways that revealed a desired character or quality of "light in place and time". They consider how to use the daylighting design to capture and celebrate the experience of time and place and to harvest free site energy from both qualitative and quantitative perspectives.

Evaluation Process

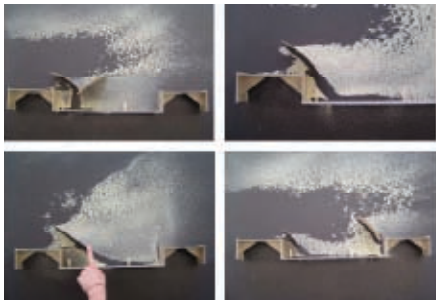
The nature of light (quality of light studies at the massing and section scales):

- Three 1/16" physical site/massing models + plans and sections
- Diurnal and seasonal photographs of the physical models
- Daylighting program based on activities (written and photographic qualities of light)
- Ecotect quantitative analysis on a diurnal and seasonal basis (footcandle analysis for 9 a.m., noon, and 3 p.m. for the equinoxes and solstices) in plan and section
- Written and graphic critique on critical daylighting issues and lessons

Evaluative Criteria

LIghtscape I: Light in Place and Time:

- Clarity, craft, and execution of design intentions demonstrated in the models and drawings (team grade)
- Clarity and accuracy of quantitative and qualitative analysis (team grade)
- Overall craft of presentation boards and drawings (team grade)



Lightscape I Analysis
Haller, Portilla, and Tupy (top)

Exploratory daylighting and thermal massing studies at the site and building scales.

Lightscapes I: Light in Place & Time (cont.)

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Cautions- Possible Confusions

The first week of the study focuses on the qualitative opportunities of daylight to inform both human expereince and to enhance the human relationship to place (and bioclimatic forces). Students should be cautioned from seeking a single "solution," and rather be encouraged to investigate multiple options through qualitative massing models and sectional studies. The second phase of the study explores preliminary programmatic implications of daylighting related to quality and quantity of light through quantitative studies with Ecotect (optional studies with DAYSIM and Radiance).

Duration of Exercise

Two weeks for Phases One and Two.

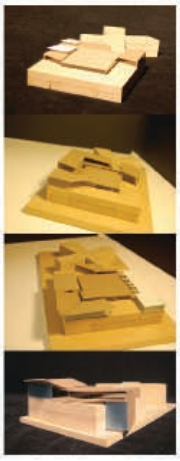
Degree of Difficulty

Introductory graduate level.

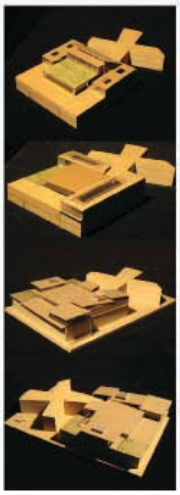
References

REFERENCE DAYLIGHTING DESIGN BOOKS ON RESERVE: See list in bibliography.

skylights



Jennifer

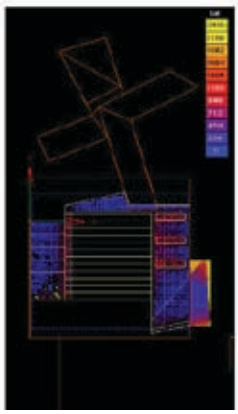


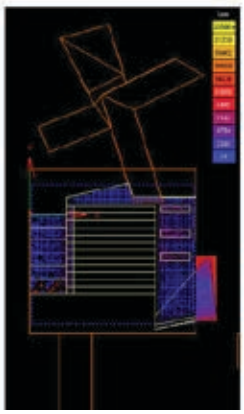
Katie

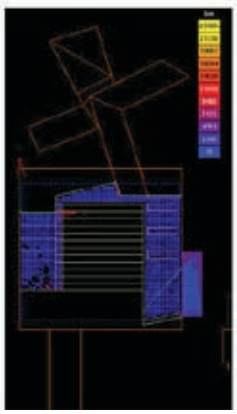
Lightscape I Analysis

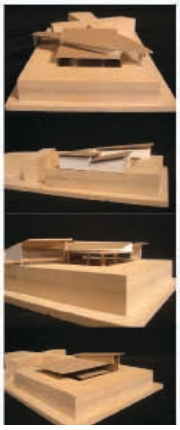
Garman, Leaf, Nicklay

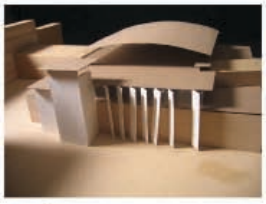
Exploratory daylighitng studies at the site and building massing scale using physical study models and Ecotect.











Jacob

Optimizing Building Performance & Thermal Loads

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

Design/Performance Objective

- To gain experience in thermal design refinement and iterative analysis.
- To develop the knowledge and skills needed to optimize passive solar design and thermal design components in envelope and environmental systems design.
- To understand and compare the metrics of thermal design performance and related impact on energy use in buildings.

Investigative Strategy

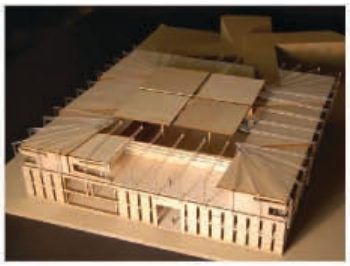
In Project Three students explored the process of design optimization through the development of a hypothesis that was quantitatively analyzed using parameter isolation, iterative simulation, and thermal assessments. Students continued to study their earlier design proposal to optimize passive thermal design parameters based on the findings of their previous daylighting analysis and conclusions. They refined the design and tested the thermal performance concerning energy optimization and passive solar design.

Evaluation Process

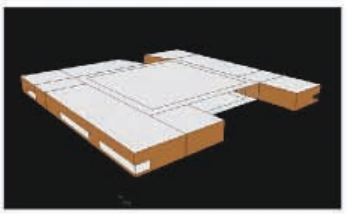
- Ecotect was used to test their hypotheses and examine the resulting impacts on building loads and other performance criteria
- Each team was asked to prepare a slide presentation to present their method or process, findings and conclusions
- Written and graphic critique on critical thermal issues and lessons and intersections with earlier studies on bioclimatic and daylighting design

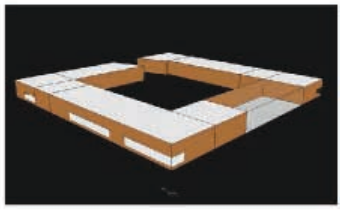
Evaluative Criteria

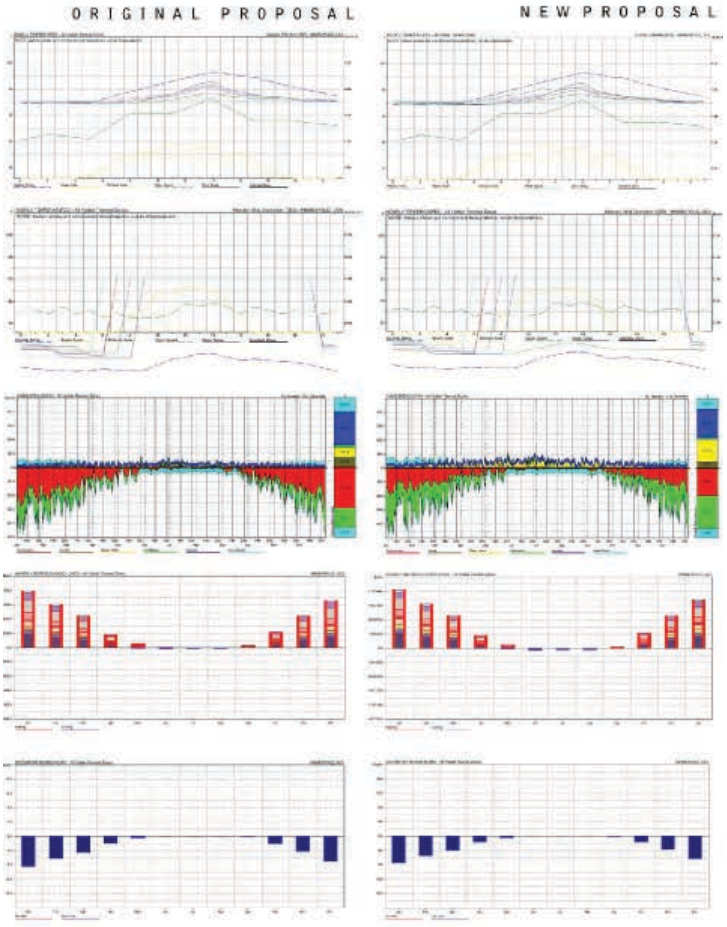
- Completeness, clarity and intelligibility of presentation
- Graphic and design quality
- Demonstration of understanding of analysis methods
- Credibility and reasonableness of findings & conclusions



The key design strategies maintained from the orginal proposal included the multi-layered building skin system that harvests free energy and the responsiveness to the existing form and conditions of Rapson Hall both in terms of program and massing.







Thermal Loads Analysis
Atta, Moua, and Park

Thermal studies comparing and contrasting thermal design strategifes and materials.

Optimizing Building Performance & Thermal Loads (cont.)

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

Cautions- Possible Confusions

Emphasis should be placed on the importance of comparing and contrasting thermal design strategies (massing, section, evelope) to understand the design implications for thermal performance. The project is intended to encourage experimentation and to gain qualitative and quantitative understanding of thermal design as it is embodied in design decisions. The project is not seeking a single answer or solution.

Duration of Exercise

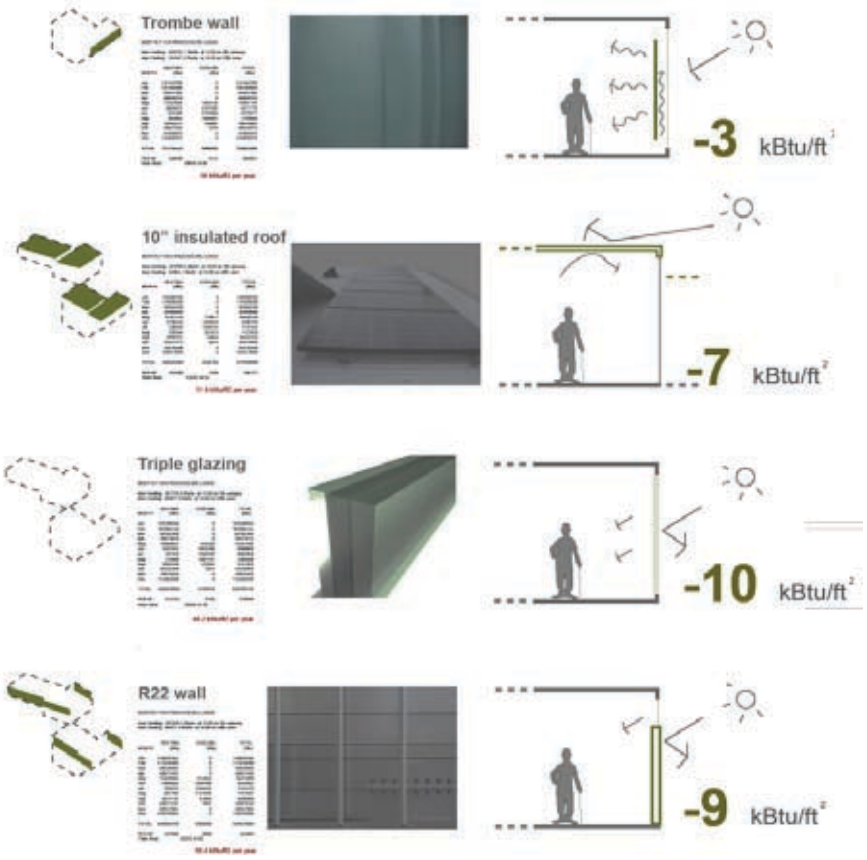
One and a half weeks for Phases One and Two.

Degree of Difficulty

Introductory graduate level.

References

REFERENCE THERMAL DESIGN BOOKS ON RESERVE: See list in bibliography.



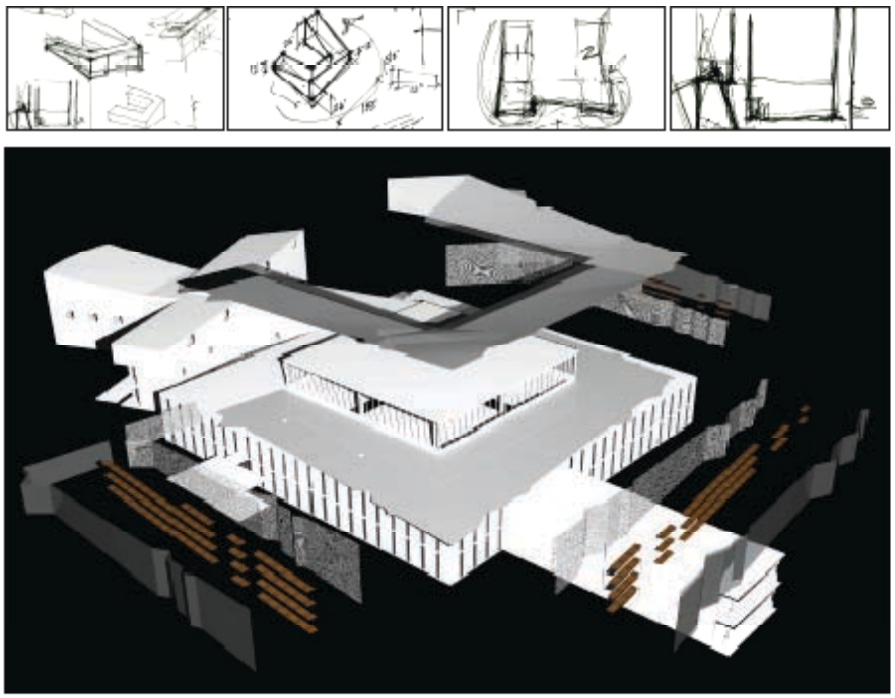
Thermal Loads Analysis
Karlberg, Voldhouse, and Young

Ecotect studies comparing the thermal performance for varied thermal and material strategies.

Ecological Envelopes: Fivefold Functionality

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design



Ecological Envelopes Analysis
Egon, LaVenture, and Tanaka

Exterior computer studies of the building envelope and shading systems.

Design/Performance Objective

- To integrate the ecological envelope design for daylighting, heating, and ventilation with other ecological opportunities.
- To foster a fivefold approach to ecological form and functionality.

Investigative Strategy

In Project Four, students revised their initial design proposal to explore the integration of ecological concepts and passive and active approaches to lighting, heating, and ventilation at the scale of the building envelope. Their challenge was to consider the opportunities of the building skin as an ecological envelope. They were are asked to consider the concept of "fivefold functionality" by exploring how the envelope might address multiple issues such as the integration of passive and active systems for heating and cooling as well as additional ecological concerns such as water harvesting, electric energy generation, creation of habitat, health and well-being, beauty, connection to place, etc.

Evaluation Process

- Three physical study models of the envelope detail at ½" scale.
- Three annotated envelope details at ½" scale.

Evaluative Criteria

- Clarity and execution of design intention demonstrated in the models
- Clarity and execution of design intentions demonstrated in the annotated sections
- Clarity and execution of precedent studies

Ecological Envelopes: Fivefold Functionality (cont.)

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

Cautions- Possible Confusions

Empahsis should be placed on the importance of comparing and contrasting envelope design strategies (section, details, materials) to understand the design implications for daylighting and thermal performance. The project is intended to encourage experimentation and to gain qualitative and quantitative understanding of the envelope design as it is embodied in design decisions. The project is not seeking a single answer or solution.

Duration of Exercise

Three days.

Degree of Difficulty

Introductory graduate level.

References

REFERENCE ENVELOPE DESIGN BOOKS ON RESERVE: See list in bibliography.

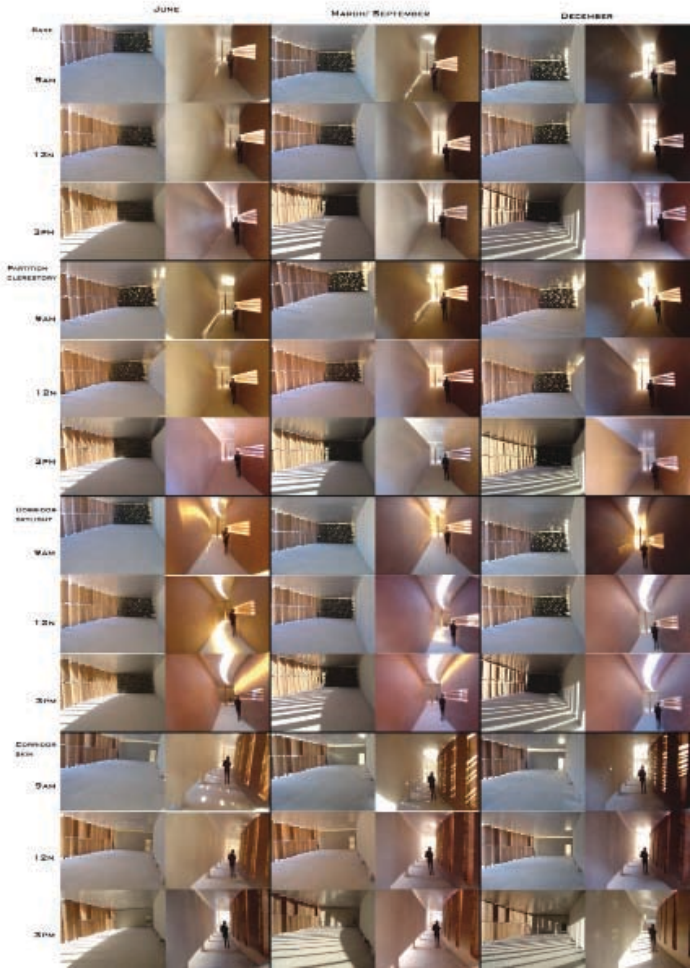
Ecological Envelopes Analysis
Duch, Fischer, and Paoli

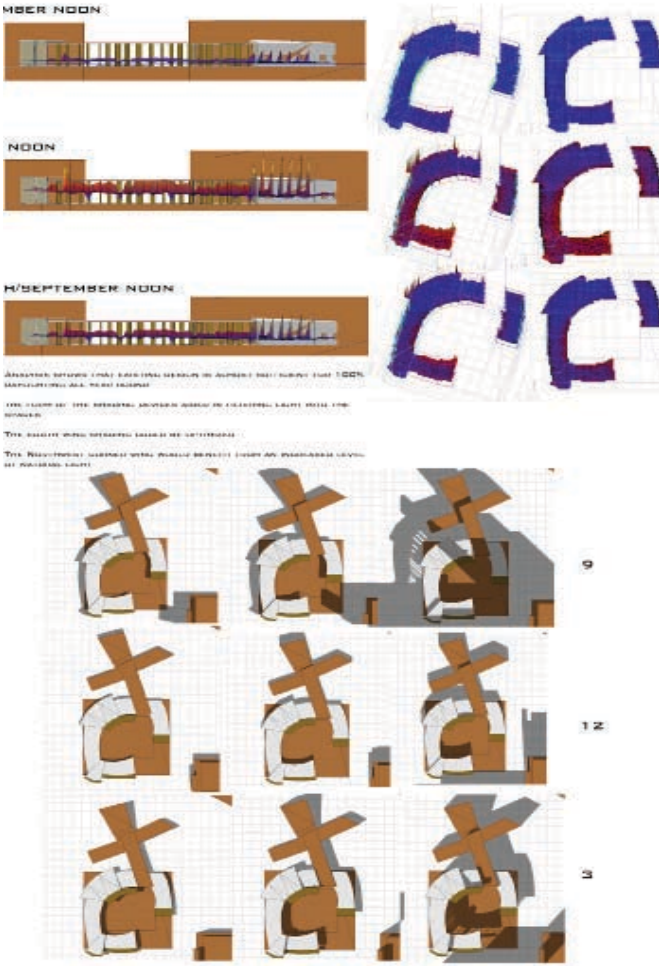
Computer and physical model studies of the interior and exterior envelope and shading systems.

Lightscapes II: Experiencing Sustainability

Mary Guzowski, Loren Abraham, Ian McLellani
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design





Lightscapes II Analysis
Markowitz, Lucas, and Ogren

Seasonal and diurnal daylighting studies using large scale phyisical models and Ecotect to evaluate qualitative and quantitative design considerations.

Design/Performance Objective

- To explore the poetic and pragmatic implications and integration of daylighting and thermal design at the scale of the room.
- To explore a serial (or parametric) procedure of design development and testing.

Investigative Strategy

In Project Five students worked at the scale of the room. They were asked to select a "typical room" or an "important room" within their project. They developed and tested both poetic + pragmatic design intentions through serial studies (parametric studies). These studies enabled them to gain a better sense of the experience of sustainability in their project while also exploring the qualitative and quantitative implications of their design investigations. This phase introduced an ecological design method that incrementally compared and tested design intentions and strategies. They were asked to bring the lessons from the room study into the overall design of their project.

Evaluation Process

- Photo-documentation of the quality of space and sun penetration studies.
- Ecotect Quantitative Studies:
  Daylight Studies: Illuminance studies on a diurnal and seasonal basis
  Thermal Studies: Hourly temperatures and passive gains

Lightscapes II: Experiencing Sustainability

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

Evaluative Criteria

- Clarity and execution of design intention demonstrated in the physical and Ecotect models
- 20%: Clarity and accuracy of parametric studies
- 20%: Clarity of intentions demonstrated in summaries, drawings, diagrams, and photographs

Cautions- Possible Confusions

Empahsis should be placed on the importance of integrating qualitative and quantitative daylighting and thermal design issues at varied scales (massing, section, details, materials). The project is intended to encourage experimentation and to gain qualitative and quantitative understanding of the intersections between daylighting and themal design. The project is not seeking a single answer or solution.

Duration of Exercise

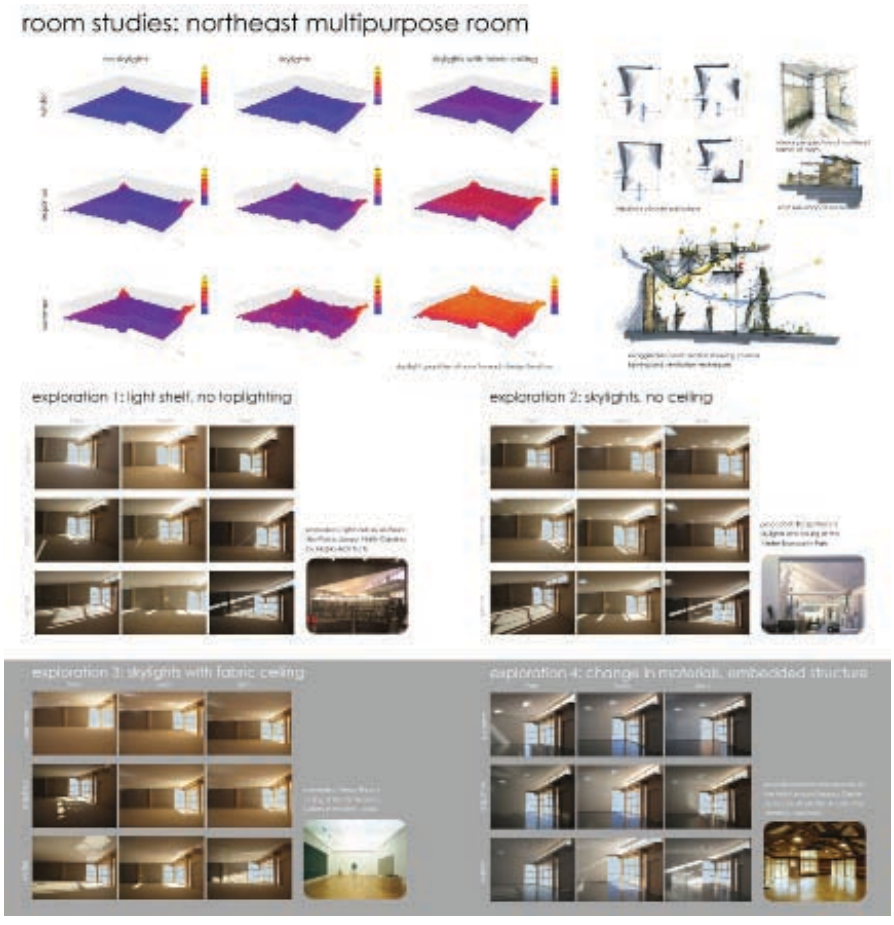
One week.

Degree of Difficulty

Introductory graduate level.

References

REFERENCE DAYLIGHTING AND THERMAL DESIGN BOOKS ON RESERVE: See list in bibliography.



Lightscapes II Analysis
Diedrich, Erickson, and Thompson

Seasonal and diurnal daylighting studies using large scale phyisical models and Ecotect to evaluate qualitative and quantitative design considerations.

Whole Building Integration

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

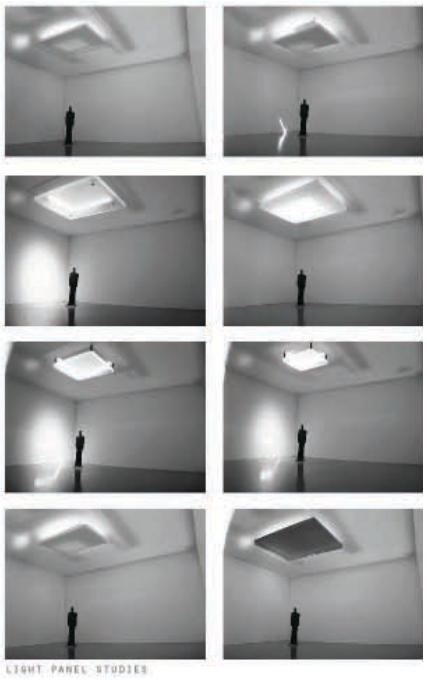
Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

INTERIOR SPACE DAYTIME

EXTERIOR SPACE DAYTIME

INTERIOR SPACE NIGHT TIME

EXTERIOR SPACE NIGHT TIME



LIGHT PANEL STUDIES

Whole Building Integration
Gordon, Hara, and Zielinski

Interior and exterior studies illustrating the quality and character of the luminous and thermal environments on a diurnal and seasonal basis.

Design/Performance Objective

- Integrate passive thermal and luminous design considerations as well as the key building systems including daylighting and electric lighting, heating, cooling, ventilation, and renewable energy systems.
- Meet the daylighting, thermal, ventilation, energy, greenhouse gas emissions, and other relevant design and ecological goals set by your team.
- To analyze the final design and compare the results to the original Baseline Case showing the estimated improvements in energy use, greenhouse gas (carbon dioxide) emissions, thermal comfort, daylighting performance, life-cycle cost and other metrics (performance measurement) of student's choice.
- To make the necessary modifications to the building model, using ECOTECT, DAYSIM, and/or Radiance to determine the resulting changes in luminous and thermal design for zero-energy and carbon-neutral performance.

Investigative Strategy

In the Project Six, teams presented a "final" iteration or evolution and evaluation of their project. They proposed an integrated design solution for the mnZED Lab Addition to Rapson Hall and compared the performance to a Baseline Case, which was their initial concept presented in Project One and analyzed as the Baseline Case in Project Two. Their "final" design proposal was informed by the analysis of incremental qualitative and quantitative design improvements made during previous projects. Students presented their findings through physical models, Ecotect studies, charts, graphs, annotated plans, sections or axonometric diagrams. They were asked to graphically illustrate how the various design strategies and related systems are integrated into a meaningful architectural and ecological whole and to consider their final energy consumption or production and greenhouse gas emissions.

Evaluation Process

- Envelope study models and annotated wall sections- minimum 3
- Daylighting studies of one important room (qualitative time sequence photographs and Ecotect quantitative analysis on diurnal and seasonal basis)
- Ecotect Studies for the thermal performance for passive solar and system integration
- Physical models and graphical systems integration studies
- Written findings and conclusions on systems integration

Whole Building Integration (cont.)

Mary Guzowski, Loren Abraham, Ian McLellan
University of Minnesota

Spring 2008 6.5 week STUDIO/TECHNOLOGY MODULE- Luminous and Thermal Design: An Ecological Approach to Zero-Energy Carbon Neutral Design

Evaluative Criteria

- Clarity and execution of design intention demonstrated in the physical and Ecotect models
- Clarity and accuracy of parametric studies
- Clarity of intentions demonstrated in summaries, drawings, diagrams, and photographs

Cautions- Possible Confusions

Emphasis should be placed on the importance of synthesizing design daylighting and thermal strategies (section, details, materials) into a comprehensive whole. Emphasis should be placed on both the qualitative and quantitative dimensions of the design to create a meaningful design proposal.

Duration of Exercise

One and a half weeks.

Degree of Difficulty

Introductory graduate level.

References

REFERENCE DESIGN BOOKS ON RESERVE: See list in bibliography.

Whole Building Integration
Gordon, Hara, and Zielinski (top)
Ruppert, Schwager, and Stream (bottom)

Ecotect analyses of thermal and daylighthing performance. Interior sections illustrating daylighting, thermal, and systems integration.