Hazem Rashed-Ali

University of Texas - San Antonio

Applications in Sustainable Design: Decision Support Tools for Carbon Neutral Design

Spring 2008 Arch 4133/ 903 (G)/ (UG) Seminar

"This course is based on the premise that there is an increasing need to integrate environmental performance considerations in the form-making processes of architectural design. While this integration can be achieved through various methods which differ according to the stage of the design process they are intended for, all of these methods aim to inform design decisions by an assessment of the expected performance of the community, building, or building component in question, which is based on measurable criteria such as energy consumption, lighting levels, solar shading and solar access, harmful emissions, or other impacts.

During the course of the semester, several assignments and hands-on exercises will be conducted in which students will apply sustainable design principles and strategies to a specific design project through utilizing the variety of performance modeling and simulation tools addressed in the class, therefore gaining experience in using these tools.

Students choosing Option A will be teamed up with students in a concurrent design studio working on a national competition with carbon-neutrality as a design objective. While not being responsible for the quality of the resulting design, students from the course will play the role of the environmental performance consultant within the design team and will therefore be responsible for conducting the necessary analysis and simulation needed to inform the design tam members using the tools presented in the course."

Studio KEY

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TEACHING TOPICS PROFILED

1. Climate Analysis

Conduct an analysis of the local climate in the city area in which your selected design project is located. The analysis should be conducted using one of the two climate analysis software presented in class: UCLA's "Climate Consultant 3" or Square One's "The Weather Tool (companion to ECOTECT)".

2. Site Analysis

Utilize the solar, shading, and thermal analysis functions of ECOTECT to identify the available natural resources for individual project sites (solar, wind, etc.), determine how to best take advantage of these resources, and then evaluate the conceptual design ideas and preliminary forms of the project.

3. Assessment of Form Options

Utilize the daylighting analysis functions of ECOTECT to identify and optimize the daylighting design of the major spaces in their project.

4. Solar Control

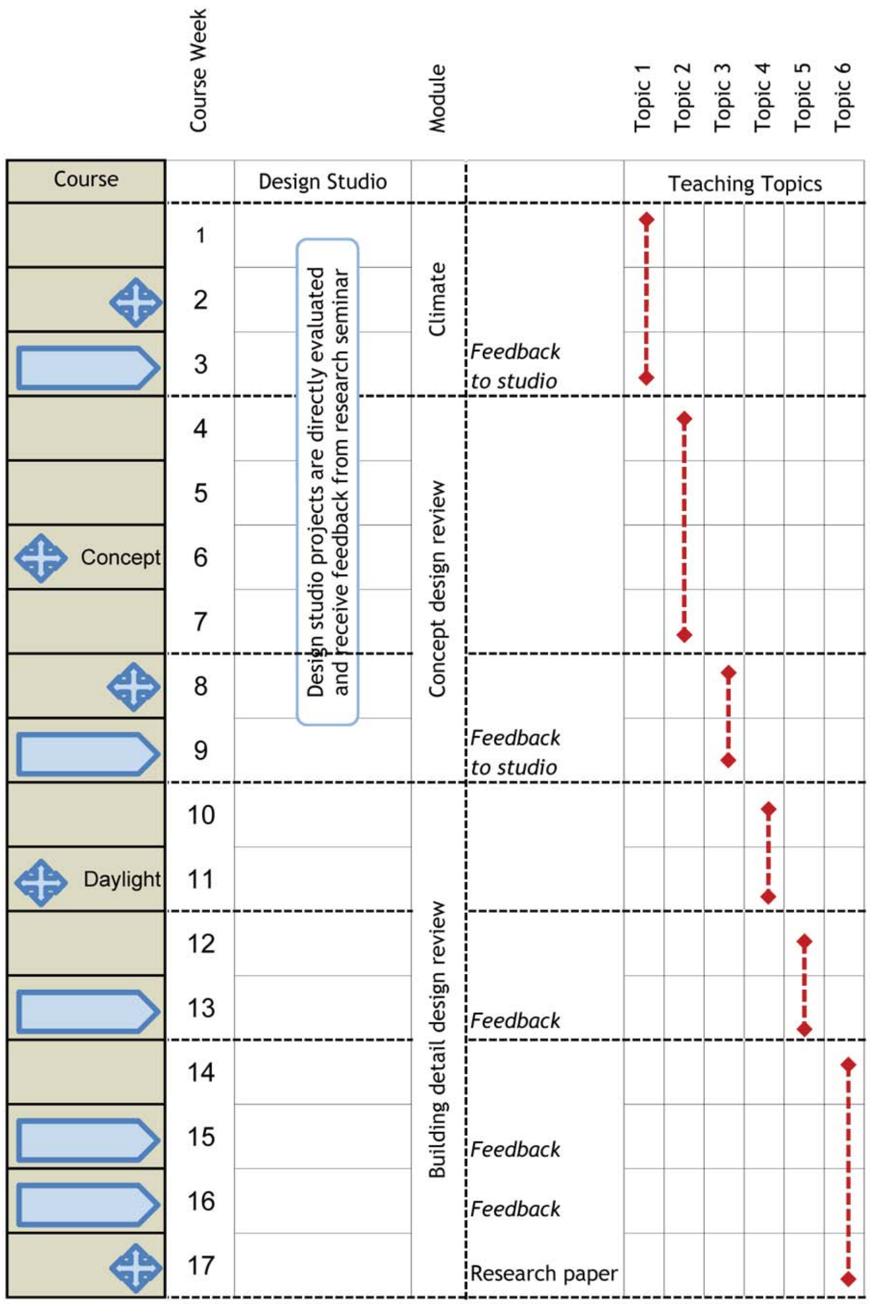
Utilize the whole building energy simulation software eQUEST in identifying the total energy use of the semester project, and then to determine the required size of the renewable energy system needed to meet this demand

5. Daylighting

Perform a daylighting analysis of one of the major spaces in the project. Using the performance analysis capabilities of the simulation software, optimize the daylighting conditions in the space.

6. Whole Building Energy Use

Understand the basic principles and procedures involved in comparing alternatives for materials and systems and making these selections based on "life-cycle" considerations as well as to become familiar with one of the tools used for that purpose



Studio KEY (cont.)

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Spring 2008 "Applications in Sustainable Design" Graduate/ Undergraduate Seminar

General Profile

This course took place in the college of Architecture, the University of Texas at San Antonio in the spring 2008 semester. The course was conducted as an elective 3 CH "applications in Sustainable Design" seminar, which was cross listed for both graduate and undergraduate students and which was conducted in collaboration with a concurrent undergraduate design studio. While the seminar was individually taught, the process was conducted in collaboration with the studio instructor: Professor Marc Giaccardo, Associate professor of architecture in UTSA. The seminar included 18 students (11 undergraduate and 7 graduate), while the studio included an additional 18 undergraduate students. Design teams were formed between students in the design studio and students in the seminar. The seminar students were asked to play the role of the environmental performance consultant within the design team and studio students were asked to utilize the results of the performance analysis in informing their design decisions. The studio included a hypothetical project with no clients.

The studio project was the ACSA steel design competition (the Assembling Housing option). This option consisted of a multistory steel residential/mixed use building in an urban high-density location anywhere in the US. The residential nature of the project resulted in the buildings, although considerably large in size, being predominantly climate dominated. All projects had the goal of being carbon neutral.

Students were assigned different locations (sites/cities) for their projects. Cities were selected based on the climate classification developed by Lechner (see Lechner:, heating, Cooling, Lighting, design methods for architects). Selected cities covered a wide range of climates including hot-humid, hot-dry, temperate, and cold. Students were required to adapt their designs to their assigned climate/city.

The program consisted of a mixed-use multifamily housing that respects the ethnically and economically diverse urban fabric. The program was to design a new steel construction with a minimum of eight levels in height....

Special Topic: Energy Simulation

The seminar utilized several performance analysis and simulation software, each aiming at performing a specific analysis task. However, much of the design analysis tasks were performed using ECOTECT. The software used included:

1.The Weather Tool:
This tool was used to conduct a climate analysis of the different selected project locations. While CoA did not purchase a site license for the software, student took advantage of the available Demo version. This tool was very easy to use and proved very useful for student to conduct detailed climate analysis. In addition to its capability to provide a graphical analysis of the main climate parameters (temperature, humidity, etc.), the tool also included the capability of assessing the impact of one or a combination of passive design strategies on the thermal comfort of the building's occupants. This feature proved very useful for student to explore combinations of passive strategies at different times of the year and to identify the optimum mix of strategies for their location.

2.ECOTECT:
The seminar heavily used ECOTECT in several of the performance simulation and analysis tasks performed including basic modeling, solar access, solar control, daylighting, and thermal load analysis. In addition, ECOTECT models were used as a basis for daylighting simulation using RADIANCE. ECOTECT proved to be a very useful, effective, and flexible tool that allows student to graphically analysis several performance aspects of their designs and to easily modify their designs and assess the impact of these modifications of performance.

On the other hand, while some students had no difficulty in learning ECOTECT, applying it to their projects, and taking advantage of its multiple analysis tools, others experienced some difficulty in acquiring the necessary skills and required additional support from the instructor and their colleagues. In general however, all students had a favorable view of the tool after the seminar and many indicated they will utilize it in their future studios. In the case of ECOTECT, a site license was purchased and the majority of the students also purchased student copies from the software.

3.RADIANCE
This tool was only utilized through exporting form ECOTECT with the aim of providing students with a method of producing accurate rendering of daylighting conditions in their projects. Most students had no difficulty performing the rendering, however, it has to be noted that exporting form ECOTECT limits the possibility of taking advantage of the capabilities of RADIANCE. Students were also hampered by the lack of windows-compatible material files.

4.eQUEST
This tool was used to conduct a whole building energy use simulation of student's final design project (after several optimizations using ECOTECT). This was needed because ECOTECT simulates only heating and cooling loads and does not simulate whole building energy use. Results from eQUEST were used as the basis for sizing a PV system and subsequently calculating the projected carbon footprint of the project. Students were limited to using eQUEST's design development wizard which reduced the number of needed inputs, thus making it possible for students to conduct a relatively quick and reasonably accurate simulation. However, the DD wizard is based on several built-in assumptions that may well affect the accuracy of the results.

5.EPA's Target Finder
This online calculator was used to identify the site & source energy use intensity for the project as well as its projected CO_2 emissions. The tool was also used to compare the energy use intensity of the project with conventional buildings of similar type and location as well as with high performance buildings (top 10%) as defined in the target finder tool. The tool was relatively easy to use and offered students a realistic benchmark to compare the performance of their projects to.

6.Athena/BEES
Both of these tools were presented as possible means of conducting a life cycle assessment analysis of building materials/systems. The tools were not addressed in detail because of time limitations and because the project focused mainly on the carbon foot print of the building during operation and not the embodied energy of materials.

Special Topic: Interdisciplinary Design

As discussed previously, the seminar was conducted in collaboration with a concurrent undergraduate design studio, and the seminar's students were partnered with students from that studio. Students from the seminar were asked to play the role of the environmental performance consultant within the design team. While this did not entirely represent an interdisciplinary collaboration since all students were architecture majors, this model did introduce students to team working skills as well to the role of environmental performance consultants within the design team.

In general, the seminar/studio model was successful and allowed the design teams (in both the studio and the seminar) to acquire and utilize several performance analysis skills which would have been difficult to acquire within the time-limitations of the studio alone.

On the other hand, some of the students in the seminar had some complaints with regard to the commitment of the design studio students to the environmental goals of the project. There were also occasional difficulties in maintaining the simultaneous timing of tasks in both the studio and the seminar. Additionally, two of the eight design groups were not able to finish their design project and thus affected the output of their seminar counterpart.

Philosophy of CND Studio Instruction

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The Teaching of Carbon Neutral Design

September 13, 2008
HMR

The need for carbon-neutral design is based on the premise that our increasing realization of the seriousness of existing environmental problems and the significant role played by the built environment in this regard makes is necessary for architects to consider different methods of integrating various environmental performance issues in the form-making processes of architectural design. Such a need responds to and is motivated by the growing interest of the built environment professionals in achieving a more sustainable and environmentally conscious buildings and communities. While this integration can be achieved through various methods which differ according to the stage of the design process they are intended for, all of these methods aim to inform design decisions by an assessment of the expected performance of the community, building, or building component in question. This assessment should be based on measurable criteria such as energy consumption, lighting levels, solar shading and solar access, harmful emissions, or other impacts. Integrating sustainability considerations in the early stages of the design process is recognized to be particularly important because of the high impact that design decisions taken in these stages have over the subsequent environmental performance of the building or community especially when aiming for carbon-neutral designs.

While several definitions of carbon-neutrality can be found based on which phases of the building’s life cycle are considered, the definition considered for the seminar/studio model described in these documents is that Carbon-neutral or ‘zero-emissions’ buildings or communities can be defined as building or communities that emit no net carbon into the atmosphere through their operation. Achieving this goal requires the utilization of both passive design strategies as well as state-of-the-art energy efficient technologies to design buildings and communities that use much less energy than current practice (taking into consideration that up to 50%-80% reductions from average building energy use intensities are possible), and then to incorporate renewable energy generation systems into the fabric of the architecture to cover the remaining demand. This seminar adopts the position that achieving carbon-neutrality requires environmental performance issues to be considered in each phase of the design process and especially in its early stages, in which major design decisions are taken. While this was somewhat difficult to achieve in previous decades because of the time constraints of these early design stages and the lack of suitable tools that can be utilized in these phases to inform design decisions, recent generation of digital performance modeling and simulation tools offers designers the possibility of achieving such integration.

In the case of architectural education, an even more urgent need exists to introduce new generations of designers to the principle of integrating environmental performance issues in the design decision making process, and to train them to utilize the latest available tools that allows them to achieve this integration. Achieving this, however, requires a change from the traditional studio format in which projects are evaluated either solely or primarily on the bases of their form/image into one in which projects are evaluated comprehensively based on multiple criteria that include issues of environmental performance, such as carbon-neutrality and/or other concerns of environmental sustainability (e.g. resource conservation, reduced impact, embodied energy, etc.), as well as other relevant design objectives such as concept development, relationship with physical, cultural, and historical context, architectural forms and spaces, aesthetics, etc. Studios should also take advantage of the available performance simulation tools, many of which are specifically designed for architects/architectural students, and train students to effectively utilize these tools in informing their design decisions; and then to evaluate student’s project not based on their claims of performance but based on actual evidence that specific performance goals have been achieved. Finally, architectural students must be taught that the design of high-performance buildings does not preclude the designer from addressing any other relevant design consideration and does not, as is sometimes claimed, necessarily result in low-quality architecture.

Teaching carbon neutral design to students of architecture requires addressing a wide range of strategies, systems, and technologies typically associated with various aspects of sustainable design to achieve carbon-neutrality. As discussed earlier, this must include introducing students to state-of-the-art design decision support and environmental performance simulation tools, currently used by practitioners and researchers, as a means of informing sustainable and carbon-neutral designs. Students should also be provided with hands-on experiences in using these tools, which they can then utilize both in their current studios as well as in their future academic and professional design activities. These hands-on exercises should also be used to demonstrate how sustainable design practices can significantly reduce the negative environmental impact of the built environment, while providing more comfortable, healthy and economical buildings and communities. Courses teaching carbon-neutral design should also cover a wide range of topics, related to achieving carbon-neutral buildings and communities, including the definition(s) of sustainability, sustainable design, and carbon neutrality; climate analysis and climatic design strategies; building envelopes and indoor thermal environment; human thermal comfort; passive and active design strategies for different climatic regions; shading and solar access; passive and low-energy sustainable systems and technologies; daylighting; whole building energy use and building energy efficiency; ventilation and indoor and outdoor environmental quality; life-cycle analysis of sustainable building materials and systems; and sustainability assessment methods and frameworks.

Covering such a wide range of topics while in the same time training students to utilize the latest performance simulation tools in the studio is frequently made difficult by the time limitations of studios which do not allow students the necessary time to address these topics and acquire the skills needed to take full advantage of these tools. Based on this, the seminar/studio model presented in these documents represents an attempt to address this problem by introducing students to these important topics and tools in a separate seminar yet allowing them to directly apply the knowledge and skills they acquire in a studio setting through the use of collaborative teams between seminar and studio students. While several issues, mostly involving organizational and scheduling, have been identified during the course of this experiment that need to be addressed in the future, the experiment was relatively successful in general and resulted in effectively introducing a much larger number of students to the issues and tools needed to achieve carbon-neutral design than would have been possible using only the studio.

Continuing the Conversation

Follow Up Discussion between
JW and HMR

JW- *Given the ability of the seminar to introduce energy simulation into the studio setting, are you able to ultimately frame the assignments such that an individual project can claim in the final boards to credibly be zero-net energy? Does that goal have any real quantifiable meaning in the classroom, as opposed to in practice?*

You seem to have many of the elements of this objective of Carbon Neutral Design listed (daylighting, solar control etc..)…. Can you describe a protocol that would put them together and lead to a credible claim of ZED by a student in your class/studio… or does the necessary objective remain to simply minimize loads and provide PV in the abstract, without a means of gauging how close to balancing those two things the design is?

It could be that at the schematic level of an architectural design studio, you simply can't talk about a carbon neutral design as a concrete goal. How do we account for the energy efficiency attributed to the selection and design of the MEP systems, for example? Given these limitations, is it still possible to establish goals for each exercise that are appropriately aggressive? How do we know what those targets are? And do the exercises in any way build on each other to capture synergistic relationships? Put another way- does the goal of zero-net energy or CND offer a measurable new way to structure education about passive, environmentally responsive design, or is that too much to expect?

HMR- My thinking lies somewhere in between the two extremes you mention. On the one hand, the use of simulation tools clearly allows for exceeding the accepted objective of minimizing loads, through the use of passive design guidelines and rules of thumb, and providing PVs with no verification of achieving these objectives. On the other hand, however, it is difficult for studio projects to credibly claim/achieve zero energy and/or carbon neutrality both because of the limitations of the schematic design stage (lack of time, details, etc.) and the fact that we cannot account for the potential savings of advanced mechanical and electrical systems (both of which you mention), or any potential integrative solutions to optimize the performance of both envelop loads and systems. While the simulation tools we have available now do allow for accounting for such savings, this requires a level of experience beyond that of most architecture students, and many of the faculty, and therefore it is only possible to use the tool defaults, which represent average, code-complaint, system performance.

However, measurable performance improvements for whole building energy use can be set and verified. This can be achieved by comparing the results of the whole building energy use simulation (in terms of EUI measured in kWh/ft2 for example) to average US building energy use for buildings of similar location, type, and size (obtained from available tools such as EPA's Target Finder). As the simulation will be based on average mechanical and electrical systems performance, performance improvement targets should be limited to possible improvements resulting from building form, orientation, envelop improvement etc. (in the range of 20 – 30% from average usage, which is still a significant improvement). There is perhaps a need for research projects that try to quantify potential location and building type specific performance improvement targets due only to architectural design improvements.

A more accurate way of verifying performance improvement, which I did not include in this offering of the course but plan to use in the future, would be so simulate a baseline building energy usage, again using code-complaint system characteristics, and compare the energy usage of the students' designs to that of the baseline building similar to the process used to verify code-compliance and LEED certification.

Similarly, aggressive performance targets can, and should, be set for each of the element systems (shading, daylighting, etc.). These goals can be derived from existing or proposed building performance standards and initiatives (ASHRAE 189, 2030 Challenge, LEED, etc.). For example, achieving the LEED target with regard to space daylighting. Yet again, these targets will probably fall short being of zero-energy for the same reasons discussed above.

The design of the assignments in the seminar did aim to capture synergetic relationships between the different systems in the building and to gradually build up from the individual components to the overall building performance. For example: relations between site resources, building form and orientation, and occupant comfort; shading and daylighting; daylighting, HVAC, and artificial lighting; etc. These relationships were discussed extensively in class.

10 Critical Issues / 10 Common Mistakes

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Critical Issues

The seminar was structured in the form of consecutive exercises and assignments that introduced students to both the important issues relating to carbon-neutral design as well as to specific performance analysis tasks and the tools used to achieve them. The following issues were addressed in the seminar:

1-Personal carbon footprint of students and instructor:
Based on their activities in the last 12 months and compared to US and international averages.

2-Passive and active heating and cooling design strategies
The principles of climatic design and the main strategies used for heating and cooling in each of the major climate regions.

3-Climate analysis
Identifying the optimum passive design strategy or group of strategies for a certain local climate.

4-Site analysis
Identifying the potentials and limitations of a specific site with regard to the availability of natural resources and the impact of adjacent building and/or natural elements.

5-Performance modeling and simulation
The principles involved in the modeling and simulation of various aspects of a building's environmental performance using the latest available tools.

6-Solar access and solar control
The principles of solar geometry and how to take advantage of the sun in colder climates (solar access) and to avoid it in hotter climates (solar control/shading). This topic should go beyond the usual rules of thumb and introduce students to the tools that allow them to assess project specific conditions and solutions.

7-Daylighting analysis and design
The principles of designing for daylighting as well as the tools used in optimizing the daylighting design of spaces.

8-Simulation of whole-building energy use
Utilizing the latest available tool to fully simulate the annual energy use of a building, and analyze the results to identify major energy consumption end-uses and how to reduce them.

9-On-site energy production
The principle of on-site power generation and some simple methods of sizing some of these systems (photovoltaic systems).

10-Carbon footprint of building
The methods and tools of calculating the overall annual carbon footprint of a building or a group of buildings. The implications of site vs. source energy use.

11-Performance benchmarking
The significance of and need for performance benchmarking as well as some of the available benchmarking tools.

12-Life cycle analysis of building materials and systems
The use of available tools in identifying and comparing the life cycle costs of buildings materials and systems (including embodied energy and other environmental impacts). The use of LCA to select materials and systems with low environmental impact.

Common Mistakes

1-Making design decisions "only" based on their formal and aesthetic implications.

2-Focusing on identifying the needs/desires of the instructor and achieving them as opposed to trying to develop their projects to their full/best potential.

3-Considering issues of performance in general and environmental performance in particular as "engineering issues" and not part of the responsibilities/tasks of an architect/designer.

4-Believing sometimes that considering environmental performance issues when making design decisions will inevitably lead to lower quality designs.

5-Not utilizing the knowledge gained in supporting classes (e.g. environmental control systems, structures, etc.) in their studio project (although blame for this can also be leveled at some studio instructors).

6-Making claims about their designs (both regarding performance and otherwise) without carefully thinking through these claims and certainly without having any reasonable verification of them.

7-Focusing on either the design process and neglecting the project outcome; or on the design product and neglecting the process as opposed to balancing both aspects.

8-In the case of the carbon neutral seminar, successfully analyzing the performance issues and implications yet failing to fully integrate them in the resulting design solution.

Supporting Material

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COURSE MATERIAL

(PDF) ARC4133-08A-COMPILATION.pdf

ARC4133-08A-Syllabus.pdf
ARC6973-08A-Assignment 1.pdf
ARC6973-08A-Assignment 2.pdf
ARC6973-08A-Assignment 3.pdf
ARC6973-08A-Assignment 4.pdf
ARC6973-08A-Assignment 5.pdf
ARC6973-08A-Exercise 1.pdf
ARC6973-08A-Exercise 2.pdf
ARC6973-08A-Exercise 3.pdf
ARC6973-08A-Exercise 4.pdf
ARC6973-08A-Final Project.pdf

PAPERS

I do have a paper based on the seminar which will be presented in the 2009 arcc research conference. The paper is still in the review stage but I would be happy to provide you with a copy once it is accepted and presented in the conference.

Climate Analysis

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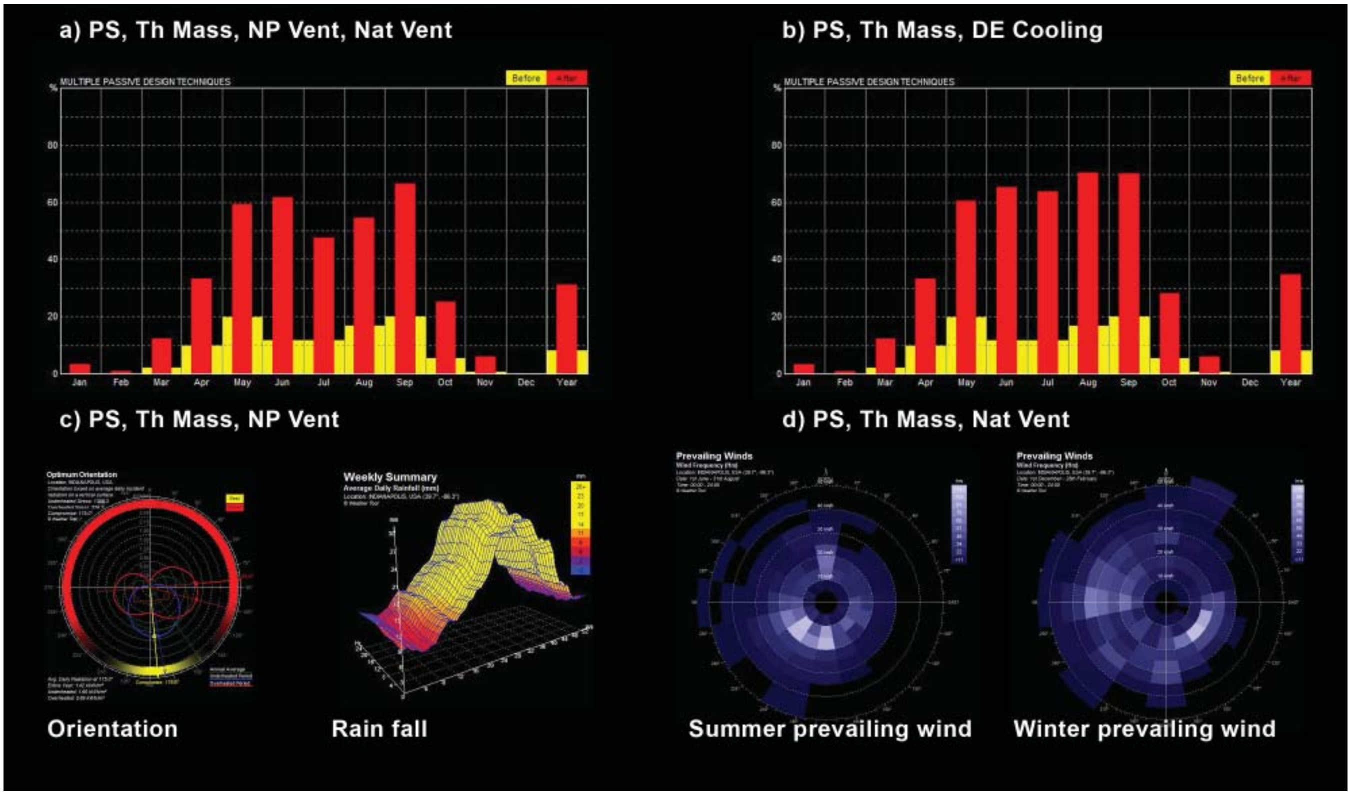

Climate Analysis
Anish Joseph

The image represents part of the climate analysis conducted for Indianapolis, IN. The bar graphs show a comparison between the percentage of hours in each month in which the indoor conditions will fall within the comfort zone boundaries using the passive strategies listed (red columns) vs. the same values without the passive strategies (yellow columns). A larger difference between the two indicates the higher potential for the selected combination of passive strategies in the climate being analyzed.

Design/Performance Objective

To conduct a detailed analysis of the local climate in the city/area in which the selected design project is located. Then use this analysis to identify the optimum passive design strategy or combination of strategies for the selected location.

Investigative Strategy

To identify and locate the climate data/ file for the selected project location. Subsequently, to conduct an analysis of this climate using Square One’s Weather Tool. The analysis included the following:

1. Identification of the selected project site (city), the corresponding weather station, and the corresponding climate region from the Lechner climate classification (see Lechner: heating, Cooling, Lighting, design methods for architects)

2. Description of the different climate parameters for the selected location, supported by graphs, generated from the climate analysis tools that sufficiently describe these parameters especially their seasonal variations

3. Summary and discussion, based on the previous analysis, of the climate in the selected location with regard to the need for heating/cooling, the availability of natural resources (e.g. solar energy, rain, etc.), as well as any other conclusions you deem relevant.

4. Analysis of the climatic design strategies (or combination of strategies) recommended for your site for each season (winter, summer, spring/fall) and for the year as a whole, supported by graphs from the analysis tool.

Evaluation Process

As described above, students were required to submit a report describing the analysis process and conclusions with regard to the most effective passive design strategy/ combination of strategies. Conclusions for each city were evaluated by the instructor and discussed in class.

Climate Analysis (cont.)

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Evaluative Criteria

The evaluation was based on the following:
- Conducting the climate analysis for the required parameters.
- The depth of the discussion of the implication of the resulting climate characteristics with regard to the building(s) performance.
- The appropriateness of the identified combination of passive design strategies to the location, their potential effectiveness (as measured by the bar graphs), and the discussion of the relationship between the characteristics of the climate and the selected design strategies.

Cautions- Possible Confusions

While weather data are available online in a variety of formats, the Weather Tool only accepts a limited number of these formats. The Weather tool however does accept .EPW weather files (freely available from the Energy Plus website listed below). Once opened in the Weather Tool, the files should be saved in .WEA format.

If a weather file cannot be located for the target city, the closest city with similar conditions and with available weather data can be used. Possible variables to take into account include altitude, topography, and distance from large water bodies.

Duration of Exercise

One week.

Degree of Difficulty

Performing the analysis involves minimal difficulty. Interpretation of the climate analysis information is more difficult and required both an initial presentation/ discussion of the topic and then discussion and analysis of samples from the resulting student work in class. Previous knowledge of the principles of climate responsive design and basic passive design strategies was very helpful.

References

US Department of Energy, 2009, Energy Plus Weather Data. Available at: http://apps1.eere.energy.gov/buildings/energyplus/cfm/r_data.cfm

Site Analysis

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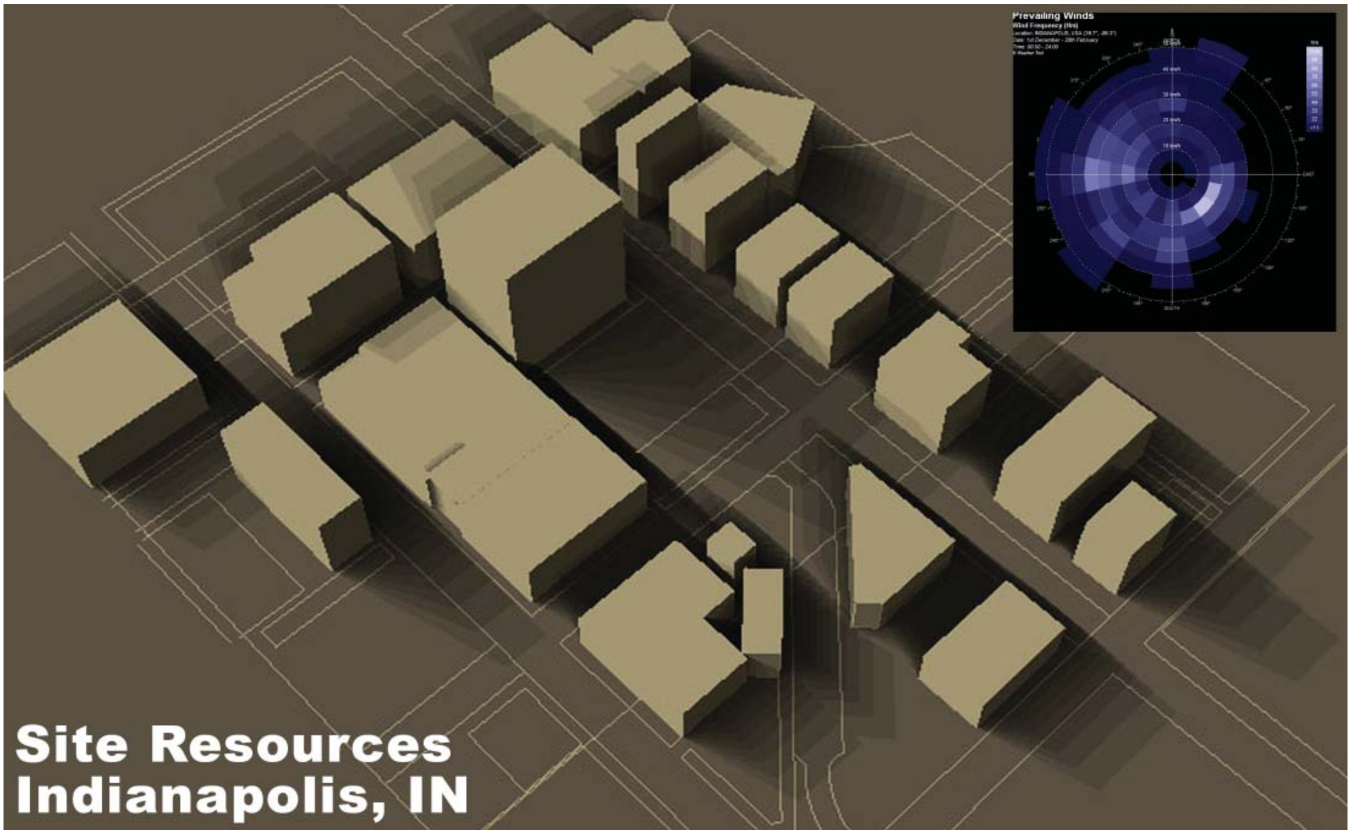

Site Analysis
Anish Joseph

The image shows a shadow range analysis of the project site. The analysis aims to identify the parts of the site with/without the availability of solar resources. The analysis aims to provide guidance for the studio students in identifying the best location for their project on the site The wind rose also indicates the prevailing wind directions which, combined with the surrounding buildings, can indicate the potential for summer natural ventilation or protection from cold winter winds as needed.

Design/Performance Objective

1. To identify the resource potentials/ limitations of the selected site/climate in terms of solar, wind, and other natural resources.

2. To determine the parts of the selected site which provide the most potential for taking advantage of these resources (taking into consideration site characteristics and surrounding buildings).

Investigative Strategy

1. Build a model of the site in ECOTECT including all surrounding buildings and/or natural features.

2. Using ECOTECT, simulate the shadow range, solar access, and wind potential of the site for important times of the year.

Evaluation Process

Students were required to submit a report describing the analysis process and conclusions with regard to the potential/ limitations of their selected sites. Conclusions for each site were evaluated by the instructor and discussed in class.

Evaluative Criteria

Students were evaluated based on the accuracy of the resource analysis with regard to the different natural resources and conditions of the selected site as well as the depth of their resulting design guidance, communicated to the studio students.

Cautions- Possible Confusions

None.

Site Analysis (cont.)

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Duration of Exercise

The task represented the first part of a larger assignment with an overall duration of two weeks. The model used in this task was also used for the remainder of the assignment (which will be discussed in the next topic).

Degree of Difficulty

The assignment has a low to medium degree of difficulty depending on the student's prior experience with digital modeling. Much of the difficulty lies in developing the site model, including site topography and surrounding buildings. Only basic/mass models are needed for those buildings.

Before working on this assignment, students were introduced to the modeling tool used (ECOTECT) over a period of 3-4 weeks, in which the different capabilities of the tool were illustrated in class and applied by the students to several independent exercises.

References

Brown, G. Z. and DeKay, M. 2000. Sun, Wind & Light: Architectural Design Strategies, 2nd Edition. New York, NY: John Wiley & Sons.

Kwok, A. and Grondzik, W. 2007. Green Studio Handbook, Environmental Strategies for Schematic Design. Oxford, UK: Architectural Press.

Lechner, N., 2001. Heating, Cooling, Lighting: Design Methods for Architects. 2nd Edition. New York, NY: John Wiley & Sons.

Autodesk, 2009, Autodesk ECOTECT Wiki, available online at: http://squ1.org/front_page

Assessment of Form Options

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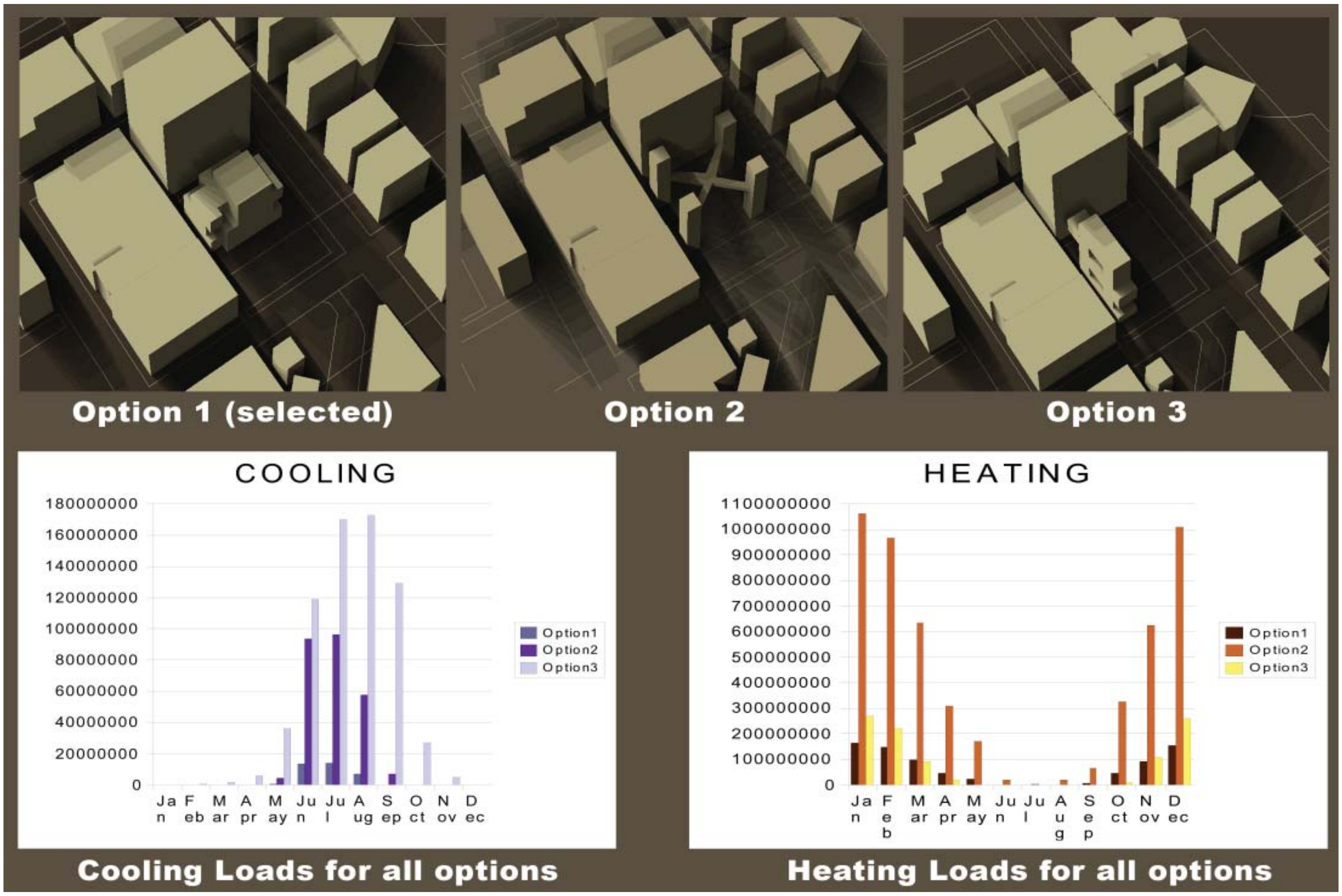

Form Options
Anish Joseph

The image shows the heating and cooling loads, generated using ECOTECT, for 3 possible form options for the design project. The graphs show clearly that option one results in the best combined (summer and winter) performance. Option two, on the other hand, results in high winter heating loads, while option 3 results in high summer cooling loads.

Design/Performance Objective

Utilize thermal and other performance criteria as one of the factors guiding/ informing the design decision making process.

Investigative Strategy

1. To utilize the passive design strategies recommendations developed in the climate analysis assignment, as well as all other design objectives for the project, to develop at least three design alternatives for the project. While the alternatives could differ in terms of form, orientation, height, utilization of site, etc.), they all had to achieve the design objectives of the project.

2.To build thermal models in ECOTECT for each of the alternatives.

3. To conduct a parametric (comparative) analysis of the thermal performance of each alternative using ECOTECT, using either the monthly heating/cooling loads parameter (for air-conditioned buildings) or the percent of discomfort hours parameter (for passive ones).

4.TO utilize the results of the thermal analysis to compare/contrast the design alternatives and to identify the future direction for your design. The selected alternative could either be one of the alternatives initially being evaluated or it can be a combination of two or more of those alternatives.

5.To conduct an analysis of the thermal performance and the solar shading/solar access potential of the selected alternative.

Evaluation Process

Students were required to submit a report describing the analysis process and conclusions supported by images from the ECOTECT analysis. Conclusions for each project were evaluated by the instructor and discussed in class.

Evaluative Criteria

The assignment was informed by the previous site resource analysis and by two weeks of exchanging information between the seminar and the studio students. Students were encouraged to collaboratively explore a variety of design/form options and to use the performance analysis results

Assessment of Form Options (cont.)

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in identifying and optimizing the best form option. The assignment was evaluated based on the accuracy of the analysis of the three options and the performance of the selected final option.

Cautions- Possible Confusions

At this stage, students only needed to develop mass models of the form options being evaluated. However, basic inputs for space usage, schedules, and other loads had to be included. Except for schedules, ECOTECT includes defaults for most of these inputs which can be used. The same inputs must be used for all the options being compared so that resulting load differences can be attributed solely to the changes in form and orientation.

Students should be made aware of the difference between results obtained at this stage, which only represent heating and cooling loads, and building energy usage, which would also include the efficiencies of mechanical and electrical systems.

Duration of Exercise

While the assignment itself had a duration of two weeks, it was building on a prior period of 3-4 weeks in which students were introduced ECOTECT and its capabilities were illustrated and applied to several independent exercises.

Degree of Difficulty

The assignment has a medium to high degree of difficulty depending on the student prior experience with digital modeling. Even student with modeling experience are typically unfamiliar with scheduling and load inputs, although these inputs are relatively easy in ECOTECT, and require some training to understand the implications of the different inputs.

References

Autodesk, 2009, Autodesk ECOTECT Wiki, available online at: http://squ1.org/front_page

Solar Control

Hazem Rashed-Ali, Ph.D.
University of Texas - San Antonio

Spring 2008 “Applications in Sustainable Design” Graduate/ Undergraduate Seminar

Design/Performance Objective

To design a solar control device for the College of Architecture (CoA) building, and to explore the use of digital simulation in this process.

Investigative Strategy

1. To use ECOTECT shading design wizard to design a solar control system for the south facing windows of the CoA annex building. The shading device was required to prevent solar penetration from the windows during the working day (8 am to 5 pm) in the period from April 11th to August 30th.

2. To generate a shading mask for one of the building’s south windows.

3. To use ECOTECT’s “Solar access analysis” wizard to calculate the “shading, overshadowing, and sunlight hours” for the south facing elevation throughout the year.

Evaluation Process

Students were required to submit a report describing the analysis process and conclusions supported by images from the ECOTECT analysis. Conclusions for each project were evaluated by the instructor and discussed in class.

Evaluative Criteria

Shading systems designed by students in this assignment were evaluated based on both their effectiveness is providing protection from solar radiation in the overheated periods of the year, as indicated by the graphics exported from ECOTECT, as well as on the innovation of these solution and their integration with the design.

Cautions- Possible Confusions

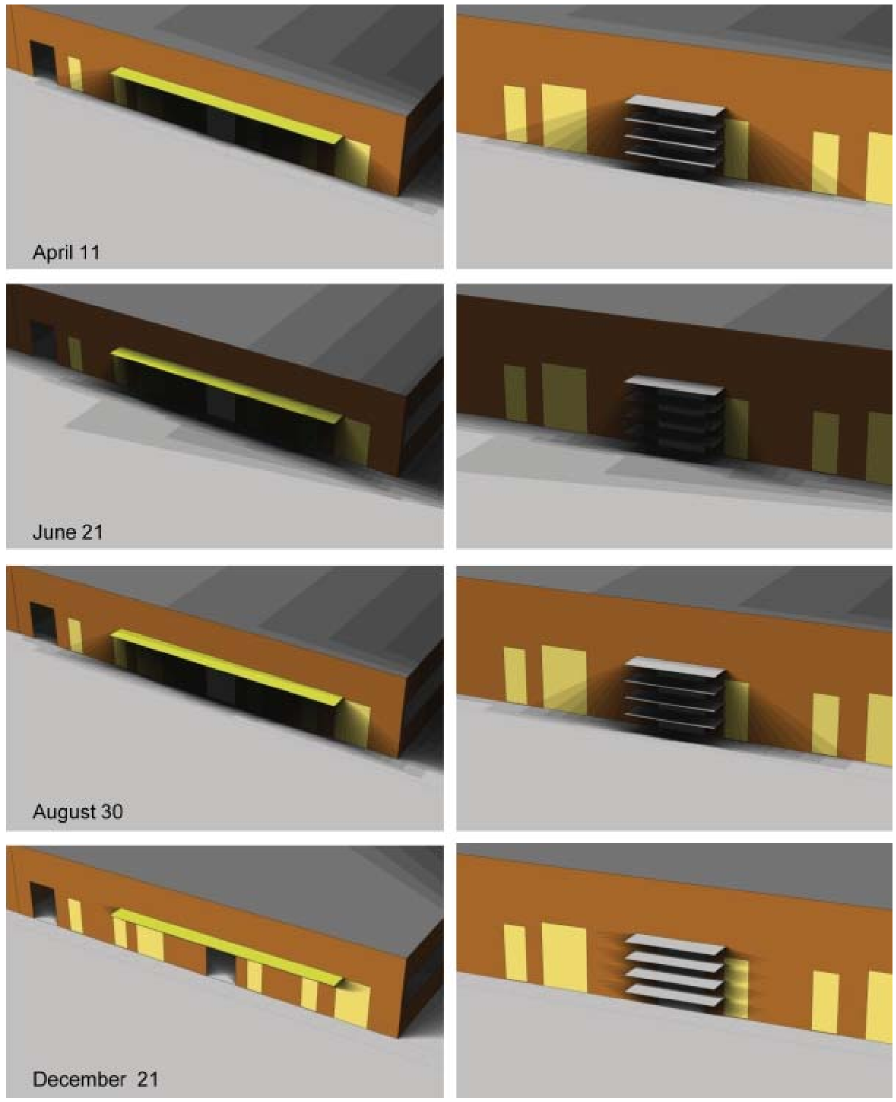
None.

Duration of Exercise

One week

Degree of Difficulty

The assignment itself has minimal difficulty. However, since this assignment uses the model(s) developed in the previous assignments, the accuracy of the shading solutions is related, to a certain extent, to the accuracy of the development of that model.



Solar Control
Chris Finke

The image shows the daily shadow range produced by two possible shading system designs in 4 critical days of the year in San Antonio, TX. Summer and winter needs were determined based on the climate analysis. For the selected climate, the successful design solution should provide maximum protection in the summer solstice and some solar penetration in the winter solstice.

At this point, students had sufficient experience of basic modeling techniques in ECOTECT, which reduced the difficulty of the model development part of the assignment.

References

Brown, G. Z. and DeKay, M. 2000. Sun, Wind & Light: Architectural Design Strategies, 2nd Edition. New York, NY: John Wiley & Sons.

Kwok, A. and Grondzik, W. 2007. Green Studio Handbook, Environmental Strategies for Schematic Design. Oxford, UK: Architectural Press.

Lechner, N., 2001. Heating, Cooling, Lighting: Design Methods for Architects. 2nd Edition. New York, NY: John Wiley & Sons.

Autodesk, 2009, Autodesk ECOTECT Wiki, available online at: http://squ1.org/front_page

Solar Control (cont.)

Hazem Rashed-Ali, Ph.D.
University of Texas - San Antonio

Spring 2008 “Applications in Sustainable Design” Graduate/ Undergraduate Seminar

Daylighting

Hazem Rashed-Ali, Ph.D.
University of Texas - San Antonio

Spring 2008 “Applications in Sustainable Design” Graduate/ Undergraduate Seminar

Daylighting Analysis
Chris Finke

The images show daylight and shading studies using ECOTECT and RADIANCE. The plans to the right show daylight factor studies produced using ECOTECT with the yellow color indicating a higher DLF. Images to the left show Radiance interior and exterior renderings exported from ECOTECT using the Radiance control panel.

Design/Performance Objective

Perform a daylighting analysis of one of the major spaces in the project. Using the performance analysis capabilities of the simulation software, optimize the daylighting conditions in the space.

Investigative Strategy

1. To identify either one “major” or one “typical” space in the student’s project in which daylighting is desirable and possible.

2. To develop a daylighting design solution for the space using either: 1) side lighting, 2) top lighting, or 3) a combination of the two (depending on the location, orientation, and size of your selected space, and using daylighting design guidelines and rules of thumb as a starting point.

3. To use the daylighting analysis functions in ECOTECT to optimize the daylighting solution to achieve the following:
- A minimum daylight factor of 2.
- An average daylight factor of 4.
- A maximum ratio or 3:1 between area of maximum daylight and area of minimum daylight

4. To demonstrate the success of the daylighting solution in providing solar control in the overheated period of the year in predominantly hot climate and/or will allow solar penetration in the under-heated period in predominantly cold ones.

5. To generate a Radiance rendering of the space at a suitable day/time to illustrate the effectiveness of the daylight solution.

Daylighting (cont.)

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Spring 2008 "Applications in Sustainable Design" Graduate/ Undergraduate Seminar

Evaluation Process

Students were required to submit a report describing the analysis process and conclusions supported by images from the ECOTECT and RADIANCE. Conclusions for each project were evaluated by the instructor and exhibited/discussed in class.

Evaluative Criteria

Daylighting solutions were evaluated based on their success in achieving the daylighting performance criteria required.
Radiance results were evaluated based on the accuracy of the model as well as the quality of the resulting daylight conditions as shown in the renderings.

Cautions- Possible Confusions

While ECOTECT can simulate DLF, its results are not accurate, and their use should be limited to comparing relative differences between solutions. More accurate DLF results can be obtained by importing Radiance results back to ECOTECT (see references).

ECOTECT's Radiance Control Panel allows for controlling most Radiance commands, yet this requires a high level of experience with Radiance. Defaults, however, yield reasonably good results.

Duration of Exercise

While the duration of the assignment was two weeks, it was building on a prior period of 2 weeks in which students explored ECOTECT's & Radiance's daylighting simulation capabilities and applied it to an independent exercise.

Degree of Difficulty

The ECOTECT DLF simulation is relatively simple and fast. However, the interface with Radiance is more difficult and the rendering process can be very time consuming.

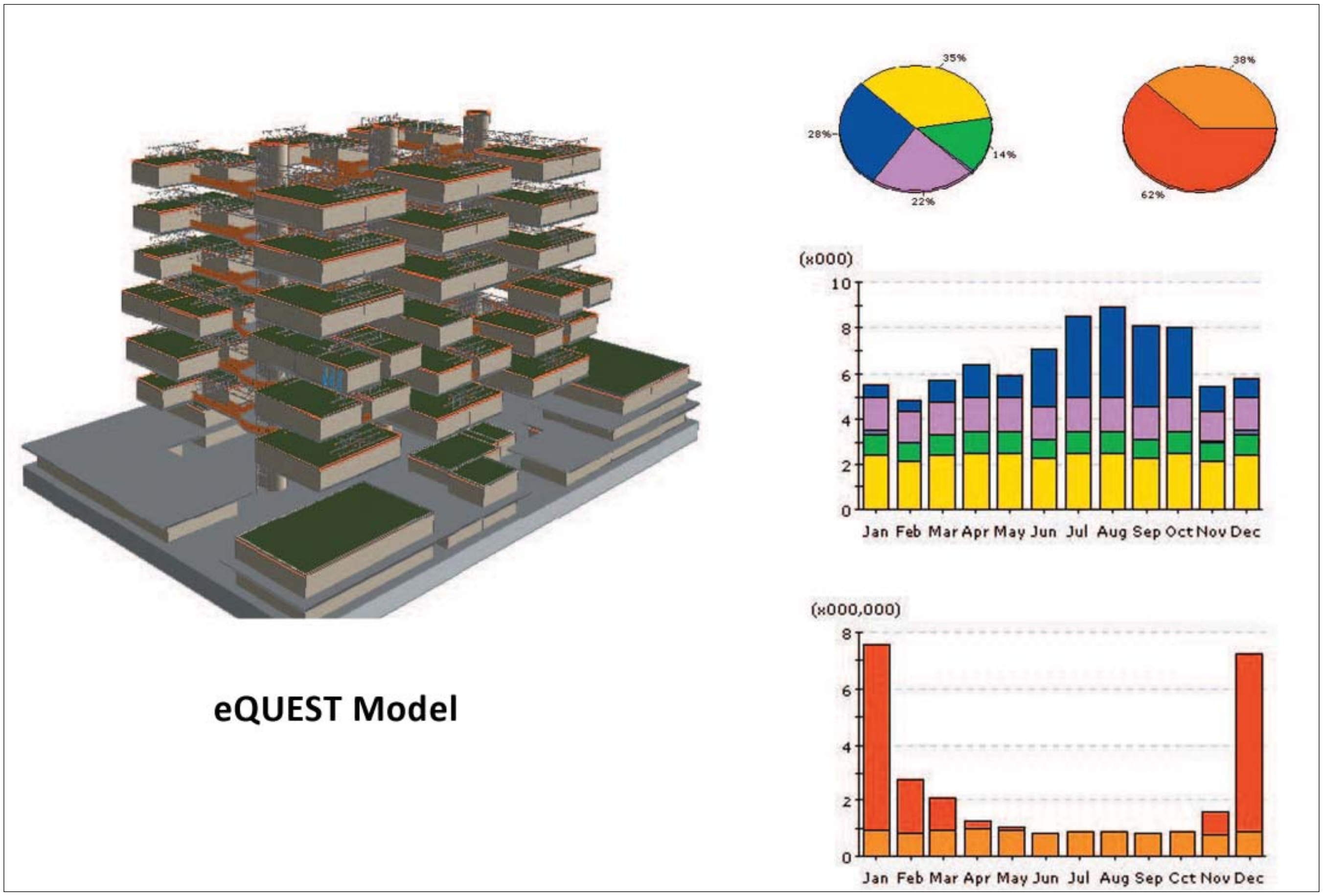
References

Reinhart, C., 2006. Advanced daylight simulation using ECOTECT, Radiance, DAYSIM, Getting Started, McGill University. Available online at: http://www.arch.mcgill.ca/prof/reinhart/software/GettingStarted.pdf

Whole Building Energy Use

Hazem Rashed-Ali, Ph.D.
University of Texas - San Antonio

Spring 2008 “Applications in Sustainable Design” Graduate/ Undergraduate Seminar



Whole Building Energy Analysis
Andrew Harwwod

The image shows the EQUEST model developed for the student project as well as the resulting monthly whole building electricity and natural gas energy use by endues. The resulting total usage is used to generate the building’s Energy Use Index, EUI, in kWh/ft2, which is then compared with average US statistics to verify the building’s performance.

Design/Performance Objective

Investigate methods/tools of simulating whole building energy use, and use the results of the tools to optimize the project’s design through comparing it with local and national benchmarks.

Investigative Strategy

1. To build a model of the project in eQUEST, using the design development wizard.

2. To simulate the whole year energy usage of the project, and to extract the “Monthly energy consumption by end use” and “annual energy consumption by end use” summary reports.

3. To calculate the Energy Use Intensity (EUI) for the project in kWh/ft2 or in Btu/ft2.

4. To discuss the different end uses of energy in the project and identify possible strategies of reducing them.

5.Using the EPA “target finder” tool, to identify the site & source energy use intensity for the project as well as its projected CO_2 emissions.

6. To discuss the energy use intensity of the project and how it compares with conventional buildings of similar type and location as well as with high performance buildings (top 10%) as defined in the target finder tool.

7.To identify possible design modifications (if needed) to improve the performance of the building relative to the benchmark.

Whole Building Energy Use (cont.)

Hazem Rashed-Ali, Ph.D.
University of Texas - San Antonio

Spring 2008 "Applications in Sustainable Design" Graduate/ Undergraduate Seminar

Evaluation Process

Students were required to submit a report describing the analysis process and conclusions supported by images from the ECOTECT analysis and RADIANCE rendering. Conclusions for each project were evaluated by the instructor and exhibited/discussed in class.

Evaluative Criteria

The assignment was evaluated based on the percentage of improvement in the building's EUI compared to average energy usage for buildings of similar location, type, and size as identified by the Target Finder database.

Cautions- Possible Confusions

eQUEST is a Graphic User Interface running a DOE 2.2 engine, which is a very complex software with the capability of controlling all aspects of the building's energy performance. Taking advantage of all of eQUEST's capabilities, however, requires extensive energy modeling experience.

On the other hand, eQUEST includes two wizards (for schematic design and design development), which allow for the control of most of its major commands, including building form and envelop characteristics, and also include reasonably accurate and location and building type specific defaults for schedules, loads, and HVAC system performance, thus making it possible for student or use the tool.

Duration of Exercise

Two weeks.

Degree of Difficulty

The use of eQUEST's wizards is relatively simple and not very time consuming. However, a basic understanding of the tool is needed using the tutorial listed below.

References

Hirsch, J., 2003. eQUEST, quick energy simulation tool: introductory tutorial. James J. Hirsch and Associates. Available at: http://www.doe2.com/download/equest/eQUESTv3-40_Tutorial.exe.