# ARCH 4150/5550 · Whole Building Analysis

## *Envisioning the Sustainable Campus*

*towards zero: integrating carbon, energy, water and ecological impacts*

## Exercise 3: Daylighting Analysis in IES VE Pro

**Exercise 3 Due Date**
Thurs. Oct. 27, 2011, 12:30 PM
Upload to Exercise 3 assignment drop box on course Moodle site

*Phase Grade weighting: 10% total grade (100 points); individual grade*

### OBJECTIVES

- To learn to evaluate daylighting performance in the shoebox model
- To become knowledgeable with various daylighting tools and performance metrics
- To learn to use various analysis techniques for optimizing fenestration design for daylighting

### Introduction

This exercise guides you in continuing to work with your "shoebox" model, as a preliminary daylighting evaluation model for your project. The shoebox model allows for optimizing design factors that can facilitate daylighting before the building design has been fully determined, and can be used to inform early design decisions, e.g., to optimize glazing types, window to floor area ratios, skylight-to floor area ratios, placement of windows, light shelves, overhangs and other aspects of fenestration and shading. In this exercise you will be asked to create a basic daylighting model and analyze it using various tools such as Suncast, FlucsDL and radiance in IES VE Pro and Daysim using the Sketchup2Daysim plugin provided. You will learn to run various simulations and get a variety of output graphic results and renderings of spaces in your daylighting model.

As before you should first verify that your model is a close approximation of the proposed design problem, i.e., verify that the floor area, no. of stories, wall area and orientation are accurate based on the initial project you chose for your study. Make any needed corrections to your shoebox and re-run the IES room identification tool. Check the *Building Properties Settings* and make sure that the location is Mpls./St. Paul and the building type is set according to your project type. Check the *default building construction settings* to see if they are as you set them previously. If not, reset them now and save them. *Save* the Building Settings and select *Room Properties*. If your model requests you to define them again, do so now. You can click either no or yes depending on whether you have assigned room names to your model. If you have, then click "Yes." Make sure that all of the rooms are properly identified. Clean up the geometry in your model as needed to accomplish this. Check to see that any surrounding structures, exterior shading devises, trees or other non-room geometry are properly designated as shading using the *Select Groups* tool. (Note: If you are not using Sketchup Pro, you will not be able to export shading objects into IES, but you can draw them in IES using the ModelIt tool. See IES VE Help for instructions on how to do this.) After you have done this, proceed to the next set of steps.

As you perform the following steps, note that:
☜ This symbol is your prompt to take an action in Google Sketchup.
❒ This symbol is your prompt to take an action in IES <VE>.
☒ This symbol is your prompt to take an action in Microsoft Excel.

You will be running all three of these programs while completing this exercise.

REMEMBER TO SAVE OFTEN!

## Exercise Three – Daylighting Analysis

STEP 1: Together with your teammate(s), you should plan a series of design conditions you wish to analyze using your shoebox model in order to determine how the daylighting performance of your project can be optimized. Pick at least 2 studies for each of your team members. It is always best to begin with a plan in mind. Don't worry if you are not sure about all of the things you want to analyze right at first. Just get something down in writing so you can begin to prioritize and make assignments within your team. You may wish to include any of the following types of analysis:

1) *"What if..?"* analysis
2) *"Apply Strategy"* analysis
3) *Parametric* Analysis (using the single variable method)

You may find the *"Zero+ Parametric Data Manager"* useful for this purpose. Download it from the Moodle Site.

For your Plan you might consider:

- *What if the windows were located higher in the walls?*
- *What if skylights were added to the roof of the building?*
- *Application of light shelves on South Windows*
- *Parametric study of window-to-floor area ratio*
- *Parametric study of visible transmittance values*
- *What if the glass type were changed to___?*
- *What if the Window area reduced (or increased) by **x** %?*
- *Application of clerestories or roof monitors*
- *Parametric study of skylight to floor area ratio*
- *Parametric study of window height to width*

Determine what you will change in your model in order to simulate that condition or set of conditions. For the Parametric studies, you will need to select a variable and a range of values or conditions you wish to model. E.g., if you are optimizing window-to-floor area ratio (WFAR) you might set the minimum ratio at 0.2 (glass area = 2% of the floor area) and the maximum at 0.2 (glass area = 20% of the floor area) and the number of iterations at 10. This will establish the various values for each iteration of the optimization study.

Assign 2 analyses in your plan to each team member and proceed to run your individual analyses. After you have completed the analyses assigned to you, review all of the results you obtained together as a team. You are free to work together or separately in running your simulations, but you will be responsible for submitting the results of your studies individually.

Steps 2 - 8 are for creating the baseline for each analysis.
Step 9 outlines carrying out the "What-if..?" types of analysis in your plan.
Step 10 outlines carrying out an "Apply strategy" type of analysis.
Steps 11-14 are for carrying out a Parametric analysis
Steps 15-16 Summary of findings and conclusions and submitting of deliverables

STEP 2: ☜ In Sketchup, open your shoebox model, verify, location, building and construction types and make any necessary adjustments. Note that the construction settings you choose will be those in your "base" model simulation. Click on the *Launch VE* tool. This is the red and green button with "VE" written on it. This will launch VE and export your model.

STEP 3: ❐ Set up your views. When the VE screen opens you should see a plan view of your model. In the model navigation toolbar at the top there is a view selection pull-down menu. Select the Axonometric view and make sure that the geometry imported correctly.

STEP 4: ❒ Click on the Suncast tool icon and run a solar shading/irradiance analysis.

A. From the *Calculations Menu* in the menu bar, select *"Solar Shading for Apache."*
B. In the window that opens the default settings should be from – *January* to *December*. If so accept all the default settings and click on the *"Start"* button.
C. Save as your baseline model under the File Name "Team_base-dl-analysis" or similar.

STEP 5: ❒ Click on the Apache tool icon and run a *"Dynamic Energy Simulation."* In the Apache Simulation window take the following actions**:**

A. Change the title of the results file to *"envelope study1-base.aps."*or something like that.
B. Set Simulation Dates:
    a. From 1 January.
    b. To 31 December
C. Click on *"Simulate"* button to run simulation.

STEP 6: ❒ Select the results options to be displayed. You are currently in *Vista.* Click anywhere in the model window and then click on the *"Energy"* button just below the model window. To the right you will see a list of reporting options. While holding down the "Ctrl" button on your keyboard, select 7 items from this list *in this order*.

*A. Boilers energy*
*B. Chillers energy*
*C. Ap Sys Aux + DWH/solar pumps energy*
*D. Ap Sys heat rej fans/ pumps energy*
*E. Total lights energy*
*F. Total equip energy*
*G. Total energy*

***Note: This is important because the order of selection will determine the order that the results are arranged.*

STEP 7: ❒ Create the results table for copying to Excel.

*A.* From the menu bar at the top of the screen, click on the *Analysis Menu* and select *"Monthly Totals."* You will see the results table in a window on your screen.
B. At the top of the table select the *Copy* icon (third one from left) to copy the entire table.
C. Switch to MS Excel application. (Note: if you are running IES on a Mac in Parallel you should be able to switch to MS Excel running in your Mac OS at this point.)

STEP 8: ☒ Transfer results data to your Base Worksheet:

A. Click on the "Base" worksheet tab at the bottom of the window and paste the results data from the base model simulation into Cell A1. It should completely replace the dummy data that is in the table.
B. **Save your Workbook file under a new name** such as "Team __DL_Study-1" or something that you will recognize later.

STEP 9: Run your base daylighting analysis:

A. ❒ Click on the *"FlucsDL"* tool icon.
B. ❒ Select all of your rooms in the browser window at the lower left of your screen.

C. ❒ Click on the *Edit* Menu at the top of the screen and select *Analysis.* This will open a dialog box *"Lighting Analysis for multiple rooms."*
   a. Under *Illuminance* select *"Planar-on the plane (Horizontal)"*.
   b. Under *Margin* enter *1'-8"*.
   c. Set the *Quality settings* on "*Low"* or 1 tier to the right of "*Low"*.
   d. Click on the *"Include a ground plane "* box.
   e. Under *Daylighting* select *"CIE standard overcast sky…"*.
   f. Under *False Ceiling*, check *"Create a false ceiling for this room"* and leave the remaining default settings as they are.
   g. Click *OK*.
   h. Save the resulting IES Report or copy to an excel spreadsheet. Close window.

D. Review *FlucsDL* results:
   a. The model view will now be displaying a contour map of the resulting Daylight Factors. Change the display from a line *contour levels* map to *filled contours using the "rainbow" button* located in the toolbar just above the model window.
   b. Click on the various other tool icons located in the toolbar to learn their function.
   c. Click on the Table Icon to get an "*Analysis Overview"* report.
   d. Save or Print this report of the Base daylighting model to a .pdf file.
   e. Check the simulation dates (to be for a full year.) If they are click on the "Simulate" button.

E. Perform a series of Radiance analyses.
   a. Click on the *RadianceIES* tool icon at the left side of the screen and in the browser below this select a rooms you would like to render.
   b. Below the model window, click on the *SkyEye* tab and under sky conditions select *"CIE standard overcast sky*." You may select any date of interest. The default is *21 September* at *noon*.
   c. Under *View parameters* select the view you wish to see. Perspective is the default.
   d. Click on the *Images* tab and under *image quality* set the sliding scale to *"Medium*."
   e. Under Generate select *Illuminance*. Click on Simulate. Experiment with the various methods of displaying the illumination level contours using the *Illuminance* menu at the top of the image. Save your image as a .jpg file and give it a name that includes the analysis being run and the room number.

   *Note: if the Overture box is checked the rendering will be a quick preview of the final rendering. In order to see the final output remove the check on this box.*

   f. Practice creating a variety of other renderings including a fisheye view of one of your rooms (select fisheye in the SkyEye tab under view parameters.) You should also try creating an *Illuminance – WP* (floorplan view.) After generating the image add contours and save as a .jpg image.

F. Review the help file for Radiance and review the functions of the other tabs including the Files/Queues (useful for running batch simulations) and the tab *Sensor Settings.* This will be useful later on in analyzing energy savings from daylighting.

***Congratulations! You have completed your first Daylighting analysis.***

STEP 10: Run your various "what if…?" or "Apply strategy" analyses. In Sketchup, return to your shoebox model. E.g., let's consider how you might add or change the window shading to your model:

A. Create shading for your South Facing Windows
    a. Draw shading devices for all of your south facing windows in Sketchup. A rule of thumb for 44 deg. N latitude is that the projection of the shade or overhang should be equal to at least ½ the window height.
    b. Group the overhangs and using the *"select groups"* tool – assign these objects as "Shade" in your model.

B. Click on the *Launch VE* tool. This is the red and green button with "VE" written on it. This will launch VE and export your model.
C. Repeat steps 4-9 for each of the analyses in your plan.
D. Contrast and compare the results.
    a. Compare the results from the base model simulation and those various simulations you performed. What are the differences in energy use? …in average DL factor and Illuminance values? Compare the rendered images with illuminance contours? How do these results compare? Is there a clear winner – one that excels over the rest?" analysis you performed in Step 9? Do the results seem reasonable? Which of the two simulations performed thus far have produced the most favorable results? What other conclusions can you draw from the analysis you have done so far?

STEP 11: Perform any parametric studies in your plan similar to Step 10. Since the amount of analysis is far greater, you may want to limit your parametric studies to only 4 or 5 iterations of analysis and you may want to limit your analysis to either FlucsDL or RadianceIES instead of both.

STEP 12: Meet with your teammates and review the findings of all your various analyses. Summarize your findings and conclusions. In your own words summarize the results of the analyses completed by your team thus far. Include a narrative summarizing the analyses performed the results of each analysis and at least 4 general conclusions that can be drawn from the contrasting and comparing of results. E.g., you might address the following questions:

1. Of the analyses performed which produced the most favorable results? How much energy use reduction was achieved in this case in terms of % of base energy use? …in terms of daylight illuminance overall?
2. What recommendations would you make based on the results? Should these strategies be employed or not?
3. What are the optimal design conditions based on your combined parametric analyses?
4. What solutions analyzed are most likely to result in excessive brightness and glare?

Step 13: Deliverables: Upload the following deliverables to the ***Exercise 2 Drop Box*** on the course Moodle Website by Thurs. Oct. 27 at 12:30pm:

1. Summary and Conclusions in .pdf or .doc file format Include your name, date, course and exercise no.
2. Submit the comparative results of your FlucsDL analyses in an excel workbook or a series of images in a pdf. File be sure to include labels on all graphic charts and radiance rendered images. Include your Name and Project. Be sure that the text size and color is appropriate and that all columns are formatted and any graphics are positioned in the worksheets so that the data can be read.
3. Submit a 3D (axonometric) graphic representation of your Proposed Shoebox analysis variations with the south facing orientation in view.
4. Optional: Submit the results of a Daysim analysis of one of your proposed strategies or designs.

*GRADING CRITERIA - Exercise 3:* 100 possible points (10% total of grade) based on the following criteria:

- Completeness of deliverables submitted
- Depth of analysis and complexity of project and daylighting strategies
- Clarity and accuracy of quantitative analysis charts and graphics
- Clarity and accuracy of conclusions drawn