By: Dan Stine

Lighting Design and Analysis in Revit

As the Building Information Modeling (BIM) "movement" continues to evolve—or mature—it is only natural that we now have more advanced features to discuss in the world of lighting design. In this article I will present an add-in for Autodesk® Revit® called ElumTools, developed by Lighting Analysts. First, we will take a high-level look at this tool's capabilities and then look more specifically at a few recent developments since this product hit the market in mid-2011 when I started using the beta version. Finally, I will briefly mention two other related offerings in the BIM daylighting-design arena.

BASIC REQUIREMENTS

The basic requirements for lighting analysis and design in Revit are highlighted in the box below. The Spatial Geometry is based on the Revit model(s). The Surface Reflectances start with the Revit material and can be changed or overridden via ElumTools. Similarly, the Luminaire is based on the Revit light fixture family and may be manipulated to a certain degree in ElumTools.

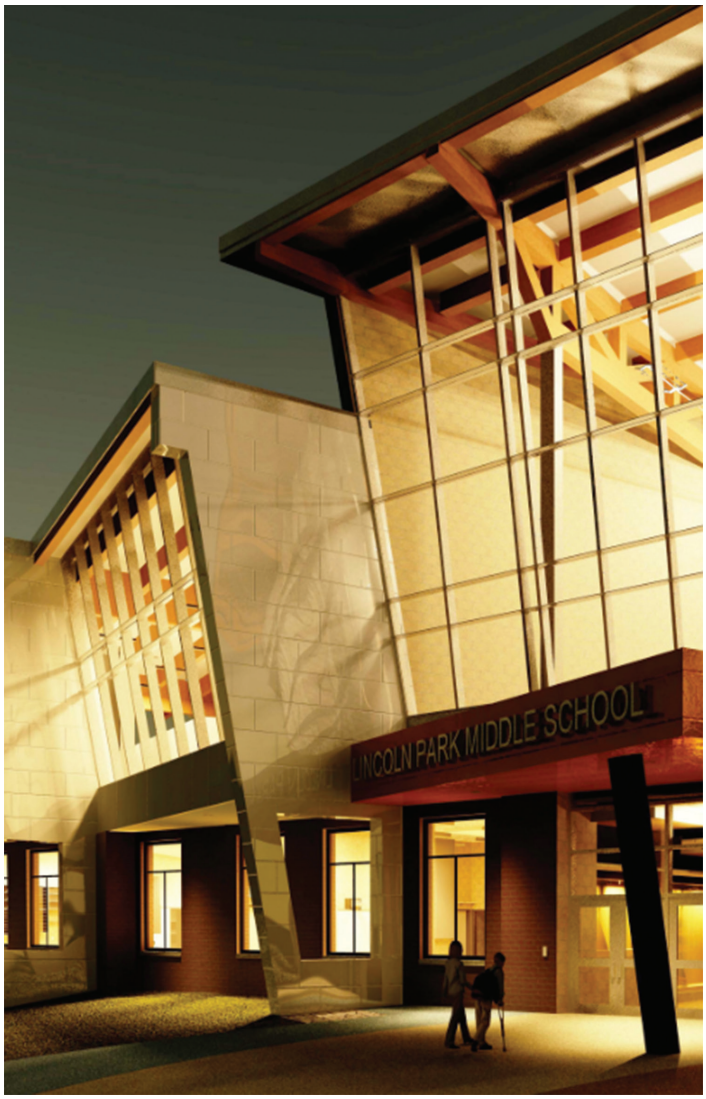
The execution of an accurate calculation of illuminance (fc or lux) on a surface or work plane requires that the following quantities be defined:

- Spatial geometry
- Surface reflectances
- Luminaire photometry and associated factors
- Luminaire position and aiming

MODEL SETUP

The following steps must be taken in Revit prior to using ElumTools.

- Typically use Spaces or Rooms
  - Best if they extend to the Level above
  - Must at least extend up to ceiling/lighting fixtures
  - FYI: Otherwise, individual elements may be selected without Spaces/Rooms as long as they are not in a linked model



Middle School designed by LHB, Inc.

- Calculate Volumes must be enabled
  - Elements defining perimeter of room must be set to Room Bounding
- Revit Materials can, indirectly, be set up to determine reflectance in ElumTools
- Revit Materials with the word "glass" or "glazing" in the name will automatically be recognized by ElumTools as being transparent, with the following exceptions: "fiber glass," "glass fiber," and "fiberglass."
- Place proper content

SURFACE REFLECTANCE

Reflectance is derived from the shading color of the Revit Material. Check out the 'Materials Mapping' help topic in ElumTools. In particular, the subsection labeled Surface Reflectance.

ElumTools uses the Graphics\Shading setting rather than the Appearance setting for a Revit Material. This is because the current Revit API does not allow third-party developers full access to this information! Even if it did, these properties do not necessarily represent the true physical properties of the material, which is essential for accurate lighting calculations (ergo, ElumTools material mapping dialog). In addition, there is no consistency between materials as far as parameters go. Check out the Appearance parameters for Carpet (1) versus Tile (4).

Reflectance = 0.2125 * R + 0.7154 * G + 0.0721 * B

Where R,G and B are expressed as numbers between 0 and 1.0 (when RGB is expressed by numbers between 0 and 255, divide by 255).

For example:
The Shading color for a specific material is set as shown in Figure 1.

Let's calculate the ElumTools reflectance for this Revit material.

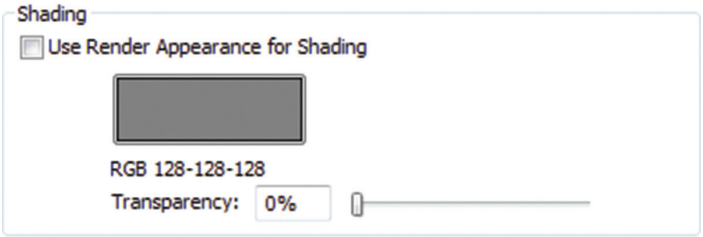


Figure 1: Revit Material's shading setting

First, modify RGB numbers for formula: 128/256 = 0.5020

Reflectance = 0.2125 * 0.5020 + 0.7154 * 0.5020 + 0.0721 * 0.5020
= 0.1068 + 0.3591 + 0.0362
= 0.5020

In the ElumTools Material Mapping dialog we see the reflectance is indeed 0.50 as calculated above.

Using this method, the reflectances can be set in Revit using specific Material settings, even in the linked in architectural model. This may be a challenge in terms of visual color desired and effort to determine correct values for a specific reflectance. It is even more challenging if the architect is not in-house or does not see that value in this effort. *Breaking news on this issue:* The folks at ElumTools are working on an option to use the defaults (such as 80/50/20) for any ceiling/wall/floor, thus significantly simplifying the reflectance workflow. Watch for this in a future release!

SPACES AND VOLUMES

It is important to be aware of the height of your spaces in the Revit model. This is true, irrespective of ElumTools. For example, if you want light fixtures or occupancy sensors on the ceiling to report which room they occur, the space needs to extend up and engage them. In the example below, the Revit ceiling elements are not able to discern which room they are in. Neither can ElumTools find the lighting fixtures or the ceiling itself, which is needed to derive reflectance.

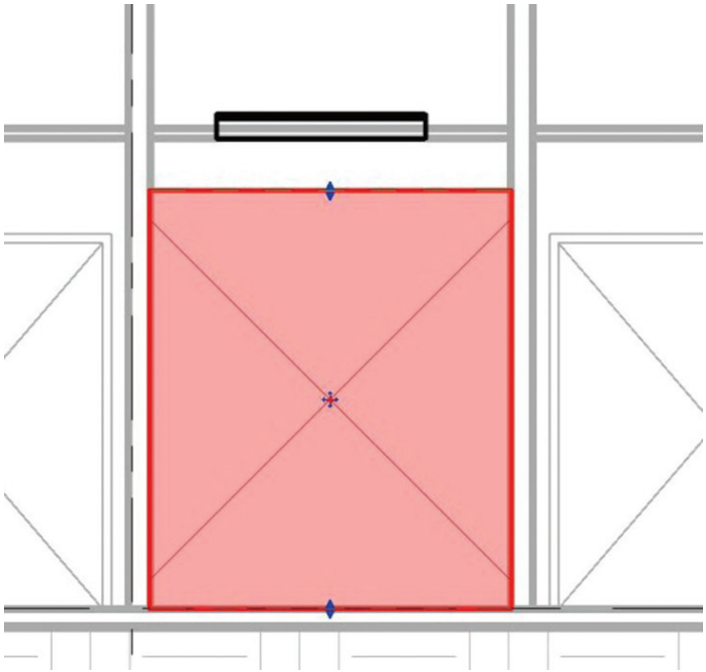


Figure 2: Selected space does not extend to ceiling or light fixtures above

For a more in-depth discussion see my Rooms and Spaces article at www.AECbytes.com.

Best Practice: Set the Upper Limit of the Space to the Level above (assuming it is not an intermediate level such as a mezzanine) and then set the Space's Limit Offset to 0'-0".

ELUMTOOLS WORKFLOW OVERVIEW

The following outline represents a high-level overview of the ElumTools workflow.

- Luminaire Manager
  - Verify light fixtures are valid (no red Xs)
  - Verify photometric file is correct
    Change via button in upper right if needed
  - Adjust Light Loss Factor (LLF) for each fixture
    Duplicate Types may be needed in Revit if multiple LLFs are needed
  - Properly position each light source
  - Apply emergency settings as appropriate
    Each fixture type has a Use Instance Parameters option
- Material Mapping
  - Verify Surface Type and Reflectance for each Material used in the space(s) to be analysed

- Important: The drop-down list at the top allows you to see, and override, materials in linked files
- The Link column can be set to None, Unidirectional, Bidirectional
- Common settings can be saved

- Add Calculation Points
  - Select a Space and then specify the point grid spacing and elevation, etc.
  - A points grid can also be added to a planar face. This allows you to study a wall
- Calculate Space
  - This allows you to select one or more spaces to calculate (all previous steps listed must have been performed prior to this)
  - Layout Assistant

    This feature can be used to automatically place light fixtures in a space based on the desired light levels
- View/Hide Results
  - This toggles the visibility of the results directly in the Revit model (uses Revit's Analysis Display styles)
- Mode Toggle
  - Toggle between General, Emergency, and Daylighting mode

  Daylighting Parameters
  - Dialog only available when Mode is set to Daylighting
  - Verify Site information

    Initial settings come from the Revit model
  - Specify Date and Time
  - Select and define Sky Condition

At this point, we will take a closer look at two newer features; Layout Assistant and Daylighting.

LAYOUT ASSISTANT

The Layout Assistant will add light fixtures to an area based on the desired illuminance for a space or room.

Prior to using this feature, the model must have the space element, ceiling, and a single light fixture. The single light fixture is required for ElumTools to connect the dots between the desired family and the host (i.e., ceiling).

When you start the layout assistant tool, you are presented with this dialog. Click one of the "Space" buttons (item #1) to select the space(s) in the model under consideration. Next, click the Luminaire button (item #2) to select the light fixture (previously placed on the ceiling in the space). Optionally, you can tell ElumTools where the ceiling grid is (item #3); this will ensure the proposed fixtures align with the ceiling grid. This is optional because it might be better in some cases to reposition the ceiling grid, rather than the lights, for ideal light distribution.

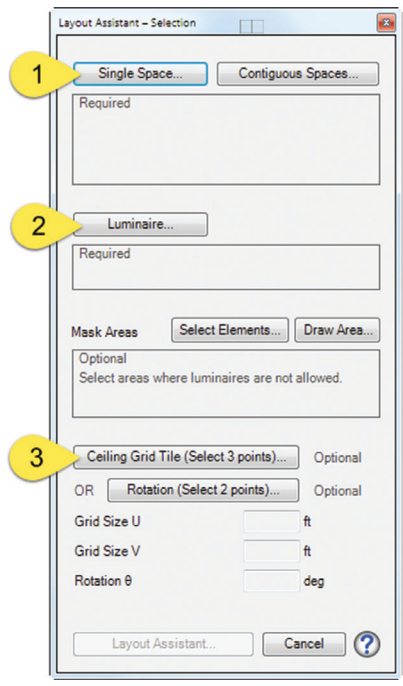


Figure 3 : ElumTools Layout Assistant Selection dialog

When the selections are complete, you click the Layout Assistant button to move on to the next step.

In the main Layout Assistant dialog (Figure 3) the lighting designer is presented with a plan view of the room—an L-shaped space in this example. The most basic workflow consists of entering the desired foot candle (fc) level (see red arrow). Immediately, ElumTools presents three rough options in the "Estimated" section. Clicking on each of the buttons in the "Estimated" section previews the luminaire layout in the space. In our example, ElumTools indicates 11 fixtures will be required to achieve 70 fc.

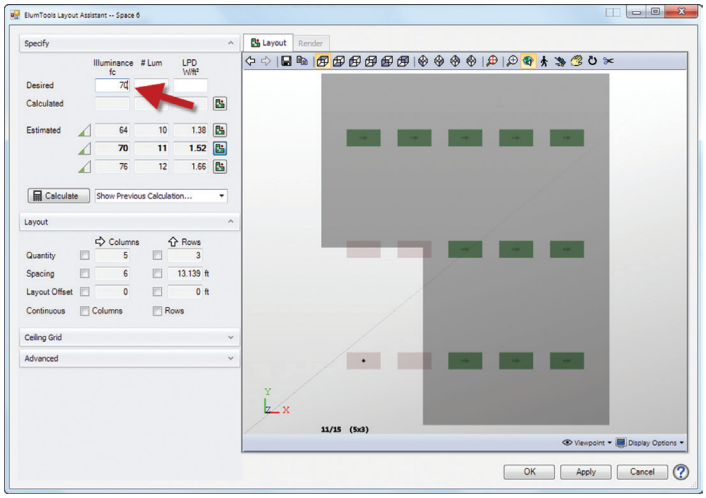


Figure 4: Entering desired illuminance

Once we have selected an estimated option we are happy with, we need to run an analysis to confirm the design. The layout assistant provides convenient access to the full calculation engine

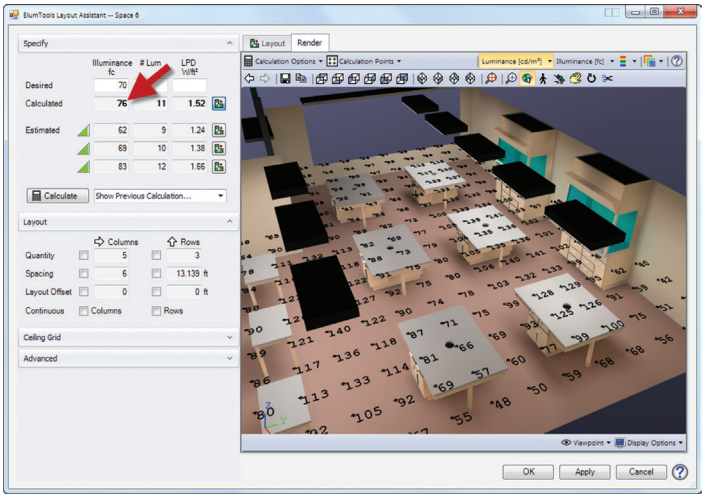


Figure 5 : Calculated illuminance

via the Calculate button. Once a full calculation is complete we can compare the Desired value with the Calculated values as pointed out in Figure 5. Also, notice how the estimated values have updated. Notice the preview window now shows a 3D view of the model with our defined grid points populated with fc levels.

Once you click OK, ElumTools places the fixtures in your model as shown in Figure 5. In this example, either the ceiling grid needs to move or all the fixtures could be selected and aligned with the ceiling grid. Also, notice that the Space Tag was edited to report the Average Illuminance for the space. This was done using the shared parameters provided by ElumTools. The FC value is blank until a calculation is run.

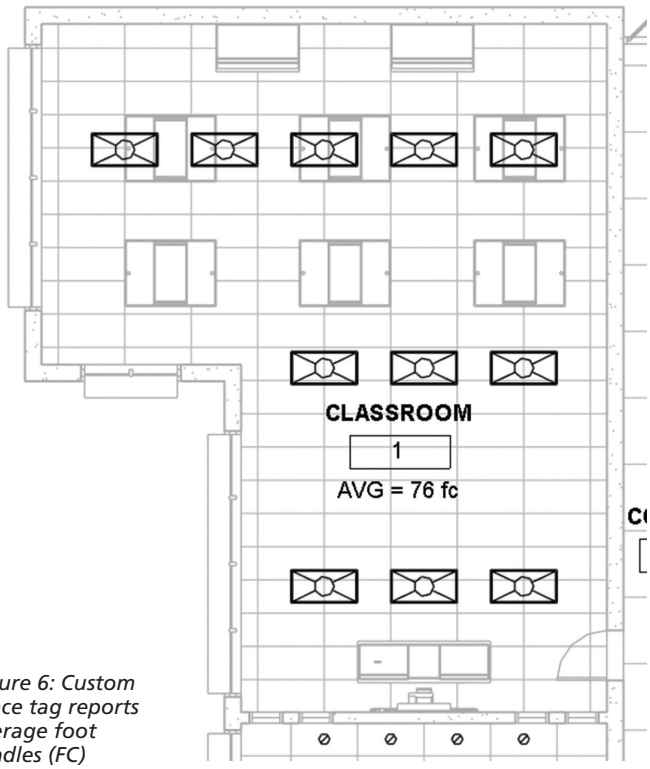


Figure 6: Custom space tag reports average foot candles (FC)

DISPLAYING RESULTS IN REVIT

Once one or more spaces have been calculated you may display the light level values in any Revit view by clicking the View/Hide Results button on the ribbon. ElumTools employs the built-in Analysis Display Styles, so some changes can be made (e.g., decimal, min/max legend, etc.) to the way the information

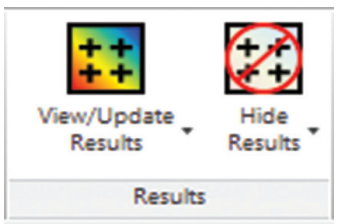


Figure 7

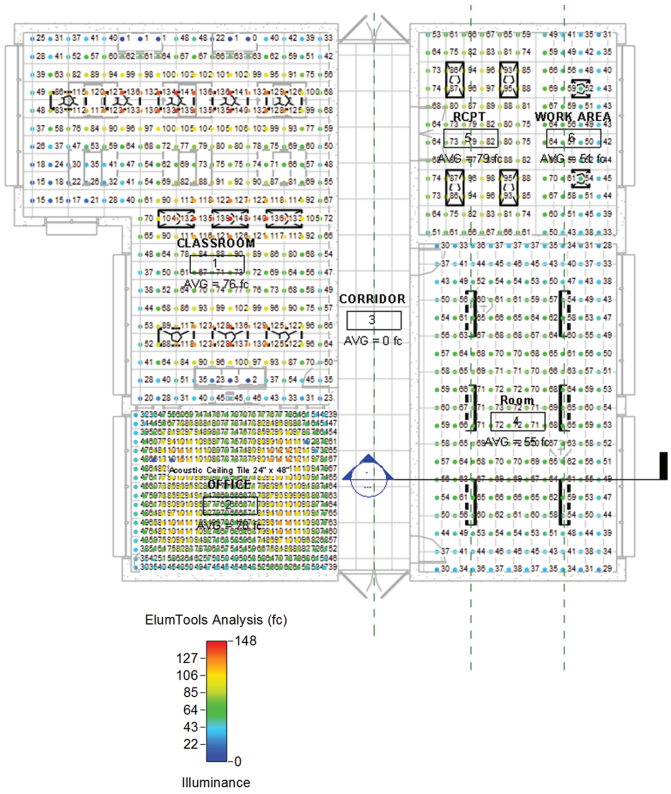


Figure 8: Calculated results displayed in Revit

is presented. The results may be hidden via the Analysis Display option for a given view's properties.

SCHEDULING RESULTS

Because ElumTools pushes all the calculated data for each space back into the Revit model, all this information can also be scheduled. The example shown here combines the space results with information about each luminaire located within it. This is called an Embedded schedule.

Lighting Analysis Schedule

Room: Number Family and Type	Room: Name Luminaire Dirt Depreciation	Illuminance Average Luminaire Lumens	Illuminance Maximum Count	Illuminance Minimum
1	CLASSROOM	76.28 fc	148.19 fc	0.41 fc
Troffer Light - 2x4 Parabolic: 2'x4'(4 Lamp) - 277V	1	8029 lm	11	
2	OFFICE	78.00 fc	125.56 fc	12.80 fc
Downlight - Recessed Can: Fluorescent - 277V	1	836 lm	4	
Troffer Light - 2x4 Parabolic: 2'x4'(4 Lamp) - 277V	1	8029 lm	4	
3	CORRIDOR	0.00 fc	0.00 fc	0.00 fc
4	Room	55.45 fc	73.07 fc	28.34 fc
Zumtobel AERO II: 60W/65 LED + 2/35W T16 Dimmable		9713 lm	6	
5	RCPT	78.94 fc	97.57 fc	51.40 fc
Troffer Light - 2x4 Parabolic: 2'x4'(4 Lamp) - 277V	1	8029 lm	4	
6	WORK AREA	51.04 fc	69.67 fc	30.68 fc
Troffer Light - 2x2 Parabolic: 2'x2'(4 Lamp) - 277V	1	3741 lm	2	

Figure 9: Lighting analysis schedule in Revit

One thing to keep in mind with ElumTools data in the Revit model, is that the same parameters are used for Normal and Emergency modes. That is, if you run calcs for a space in "Normal"

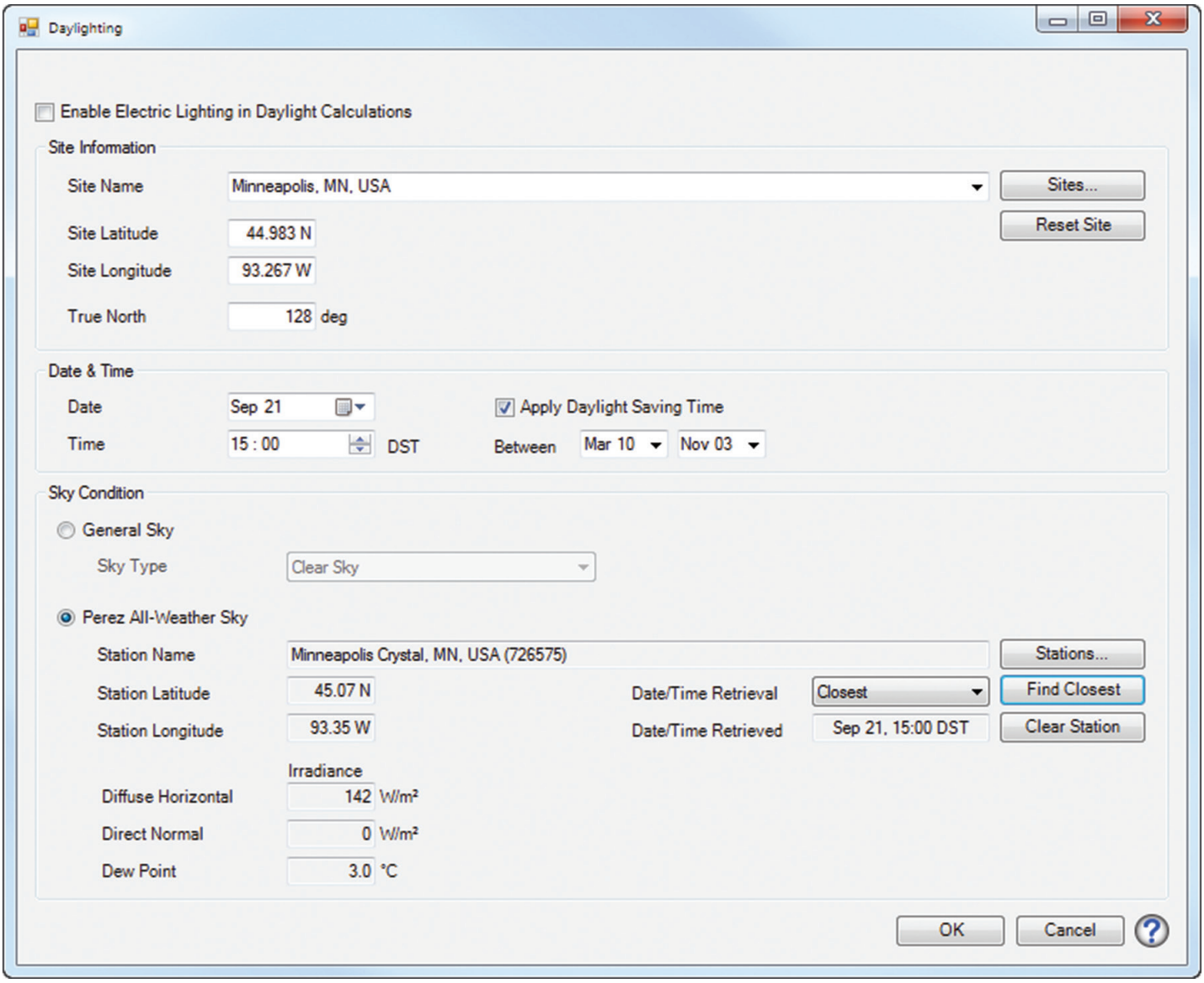


Figure 10: Elumtools Daylighting dialog

mode, and then run calcs for the same space in "Emergency" model, the normal data is overwritten. This will affect Revit tags and schedules. So, per this scenario, once the emergency design results have been confirmed, switch back to normal and run the calculation again to restore the "Normal" dataset.

DAYLIGHT DESIGN

The newest feature to ElumTools is the ability to calculate light levels in a space from the sunlight and skylight at a given day and time.

First, the location and true north must be specified using the normal Revit steps; Manage * Location and Manage * Position * Rotate True North (in a view with Orientation set to True North).

Next, similar to artificial lighting workflows, one would need to verify the Material Mapping and add Calculation Points to a Space.

To select the daylight specific options, simply change the mode to Daylighting to reveal the Daylighting Parameters button on the ribbon.

The Daylighting dialog, Figure 10, initially gets its Site Information from the Revit model. However, this can be changed manually here if needed. The date and time must be set for accurate results. Finally, the sky conditions must be selected. There is an IES and/or CIE sky model option (clear, partly cloudy, overcast) and then we have a more accurate option tied directly to our project's micro-climate via weather station data. This latter option, the Perez All-Weather Sky method, uses historical weather data to better approximate the sky conditions for the selected day and time. One simply needs to select Find Closest to quickly list the correct weather station.

Graphically, the results are presented the same as the images shown previously in this article—using the specified point grid with values reported based on light entering the space through exterior glazing.

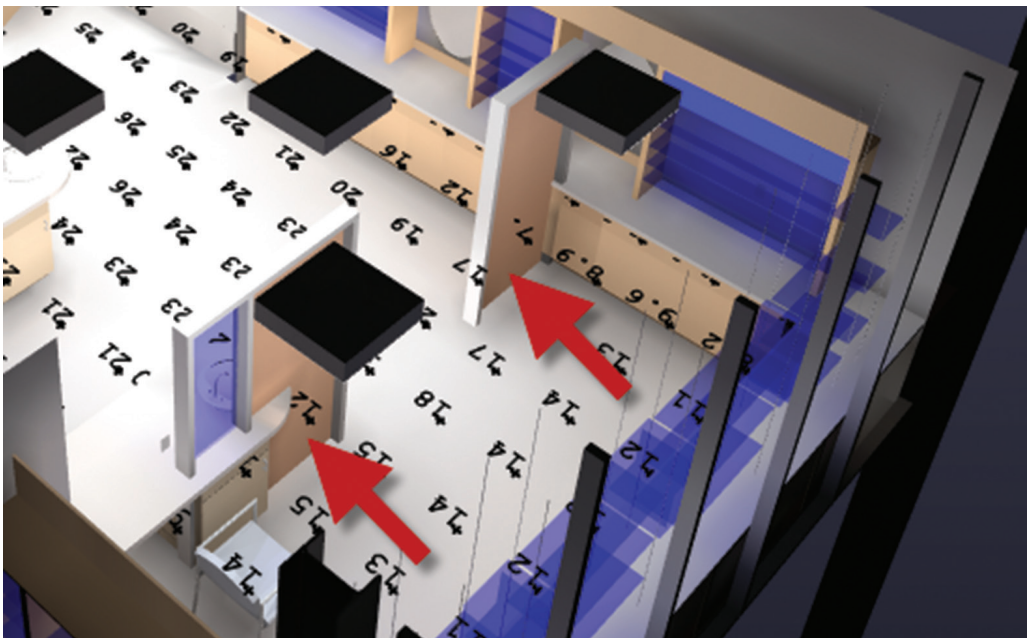


Figure 11: Problem filtering out demolished elements

ENHANCED 2014 GEOMETRY VALIDATION

One last thing worth mentioning—there has been a challenge with existing items, set to be demolished, showing up in the lighting analysis (Figure 12). This, I am told, has to do with some limitations in the Revit API. However, the folks at ElumTools came up with another way to achieve the desired results.

When enabling the "Filter by View Visibility" setting, ElumTools will automatically create a 3D view named ElumTools_WorkingView. Anything not visible in this view will be excluded from the calculations. This can be quite powerful as it accounts for phases, design options, visibility graphics, view filters, etc. If you see undesirable results, you open the ElumTools_WorkingView and hide anything you want. The next time a calculation is run, the items hidden will not appear in the analysis.

AUTODESK DAYLIGHTING CLOUD SERVICE BETA

Autodesk is working on a daylighting solution geared towards LEED IEQc8.1 2009 compliance. The analysis is all done via Autodesk Cloud Services so you have to log in first. The results are presented graphically in Figure 12 and a room schedule is created in your Revit model.

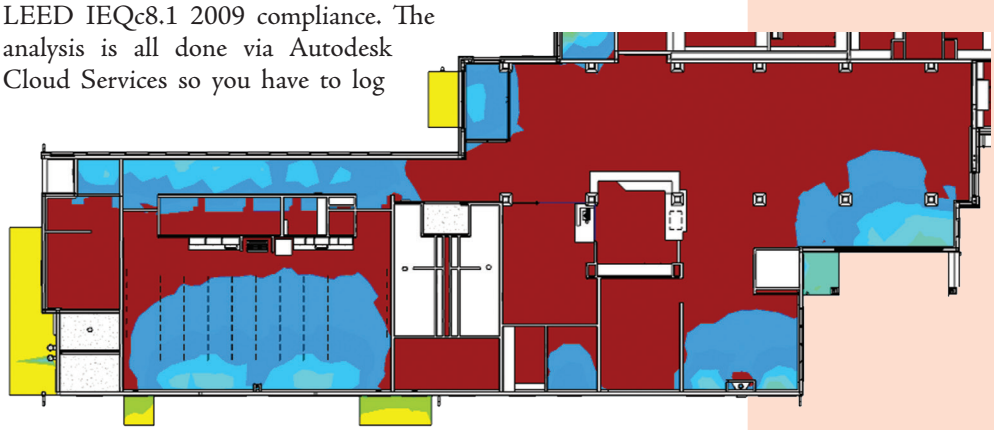


Figure 12: Autodesk daylighting analysis results in Revit

SEFAIRA

As a building performance design tool, Sefaira now offers daylight and glare analysis in their real-time SketchUp add-in. This feature set is not supported directly in Revit. However, Sefaira does have a Revit add-in to export the geometry to Sefaira.

CONCLUSION

As you can see, the ability to do lighting analysis using third-party software in the Building Information Model has come a long way in recent years. These tools significantly reduce the time necessary to do the analysis. I am sure these tools will continue to evolve and provide even more features and speed for lighting designers.

Dan Stine is a registered architect with 23 years of experience. He currently works at LHB, a 250-person multi-discipline firm in Duluth, Minnesota, as the BIM Administrator, providing training, customization and support for two regional offices. Dan is a member of the Construction Specification Institute (CSI) and the Autodesk Developer Network (ADN) and has taught AutoCAD and Revit Architecture classes at Lake Superior College for the Architectural Technology program. Dan currently teaches BIM to interior design students at North Dakota State University (NDSU). He has presented at Autodesk University, the Revit Technology Conference, and Minnesota University. Author of a number of textbooks, Dan has included a 40-page ElumTools tutorial in two of his 2015 Revit textbooks, Design Integration using Autodesk Revit 2015 *and* Interior Design using Autodesk Revit 2015. *Dan has presented on ElumTools at the last two Revit Technology Conferences in North America and will be presenting some of the new information touched on in this article at this year's conference.*