

IEA SHC Task 27: From optical performances characterization of a redirecting daylight material to daylighting simulations

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Optical performance characterization: principle of virtual goniophotometry

Efforts were made to characterize the optical performances of daylighting components in order to perform daylighting component performance analysis as well as daylighting simulation using usual daylighting software. Usual optical performance characterization involves experimental goniophotometry with the measurement of bi-directional distribution functions of reflectance and transmittance.

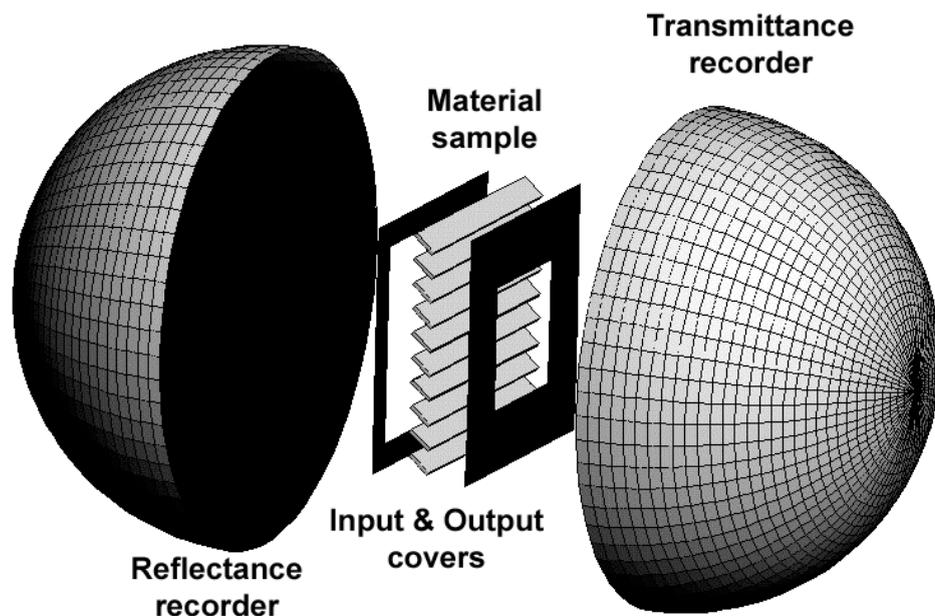


Fig. 1 Virtual goniophotometer components

Our aim was to characterize the response of the daylighting component to a given illumination condition also including outdoor conditions (ground, site surroundings like buildings and or vegetation) (Fig. 2). From indoor point of view, such a response of the system to outdoor illumination can be seen as a new source-like equivalent illumination condition at the interface between indoor and outdoor.

This can be described by mean of virtual goniophotometry ray-tracing software (Fig. 1), where the geometry of system is described by mean of CAD input, and the photometry by reference of either materials library or physical laws implementation. In order to avoid boundary effects, input and

output covers might be necessary to restrict the illuminated area of the system. Optical rays are generated from outdoor illumination source (either direct or indirect) to the system, and collected over two perfect absorbers, one for reflection and one for transmission, and recording each impact. Depending on the continuity property, raw-collected data may then be interpolated or not, and described using IEA SHC Task 21 Raw data format for bi-directional quantities.

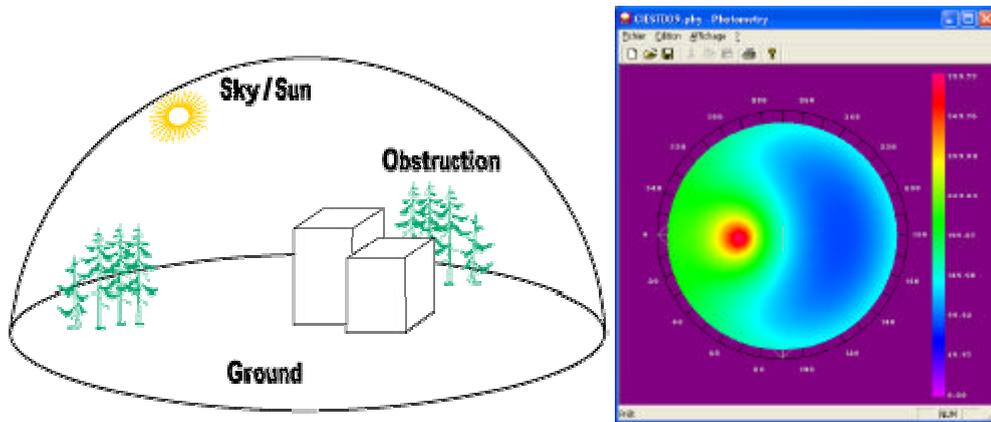


Fig. 2 Outdoor components of equivalent light source input (left), and visualization of CIE Standard sky N° 09 (right).

According to this principle, software components have been developed, and assembled together into a virtual goniophotometry application software. Input data and parameters are prepared by mean of a wizard including outdoor description, sample and covers description, recorders, and finally simulation control (Fig. 3).

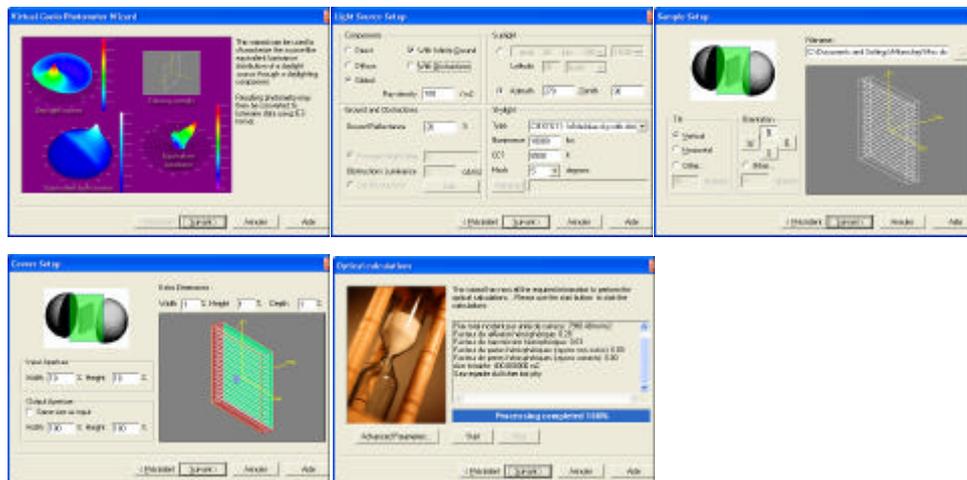


Fig. 3 Wizard panels of the virtual goniophotometer ray-tracing software. Panels include (from left to right, and top to bottom) a) introduction, b) light source description, c) sample description, d) apertures description and e) final calculations

Redirecting daylight material description

Because it offers at the same time view through the window, and ceiling illumination by sky (Fig. 4), the interesting Serraglaze product has been chosen as the redirecting daylight material sample. A Serraglaze (SG)

window is typically a mosaic made of 2 x 2 x 250 mm square SG panel array glazed between two panes of 3 mm glass.



Fig. 4 Operating principle of the Serraglaze product (left), and view through the window (right).

The SG panel edges are cut clean and square and butted together (Fig. 5), and the autoclave lamination process is using PU laminating film.

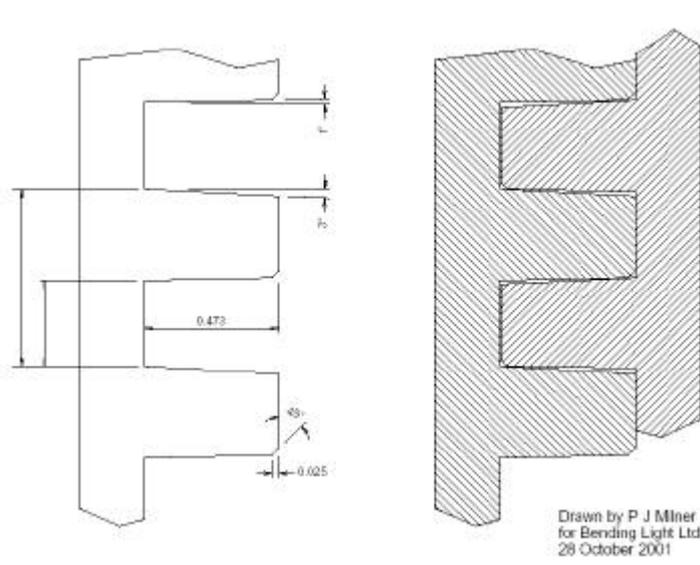


Fig. 5 Profile and assembly principle of the Serraglaze product.

The profile of the Serraglaze product has been modelled using CAD software, as an input to virtual goniophotometer raytracing software. In order to avoid boundary effects, several SG edges (a total of 20) have been described within the model (Fig. 6).

Characterization results : light source equivalent distributions

The Serraglaze product has been tested in virtual goniophotometry, and compared with simple glazing as reference case (Fig. 6). The configuration was using a vertical sample, with no ground and no outdoor obstruction. Several illumination conditions have been tested, with one case for each CIE Standard Sky, thus leading to a total of 15 skies.

Characterization results were expressed as photometries using bi-directional raw format data of IEA SHC Task 21 (Fig. 7), and also expressed as luminaire data using standard IES format (Fig. 8). Visualization and other Input/Output software may be obtained from IEA SHC Task 27.

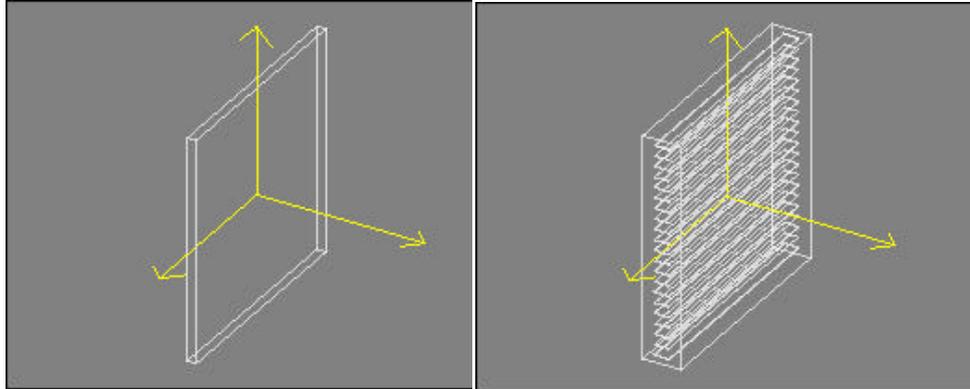


Fig. 6 Sample geometrical description (CAD input), with simple glazing reference case (left) and Serraglaze (right).

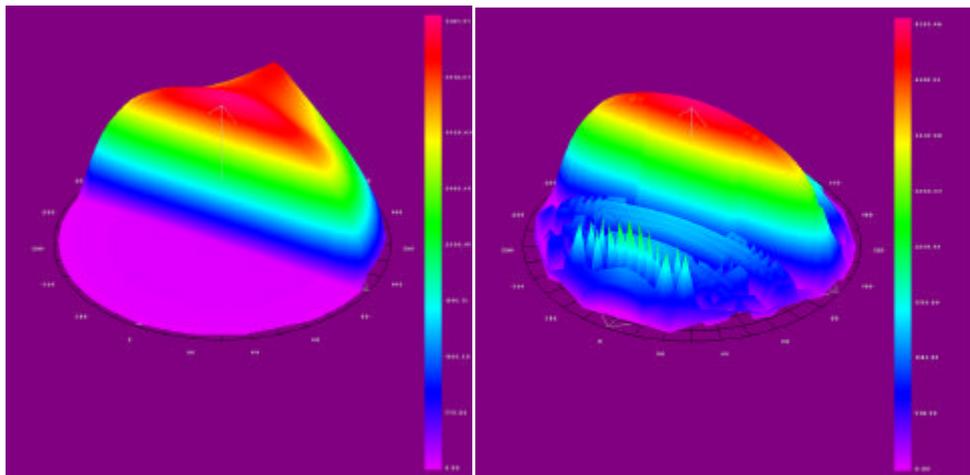


Fig. 7 Light source equivalent distribution of intensities of simple glazing (left) and Serraglaze (right) under CIE Standard Sky N° 09 illumination.

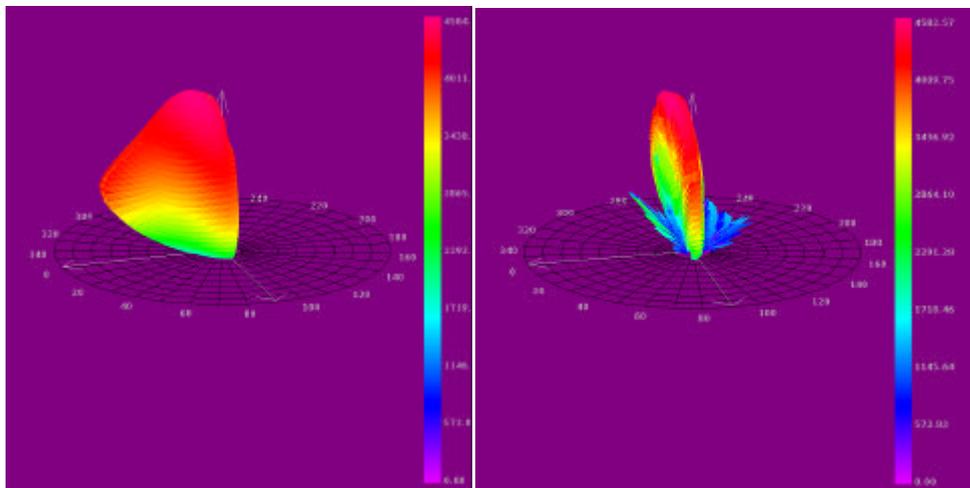


Fig. 8 Luminaire equivalent IES distribution of intensities of simple glazing (left) and Serraglaze (right) under CIE Standard Sky N° 09 illumination.

From Fig. 7 & 8 analysis, it is obvious that the Serraglaze product redirects the light coming from zenith parts of the sky toward the ceiling, while the light coming from the horizon part of the sky remains globally unchanged.

Daylighting simulations

In order to use virtual goniophotometry results as input to daylighting simulation, an office test room has been proposed (Fig. 9), with two occupants within the room, and variable length. The window system is an assembly of two tiltable parts, with lower part consisting of simple glazing, while upper part consists of either simple glazing (left pictures) or Serraglaze (right pictures).

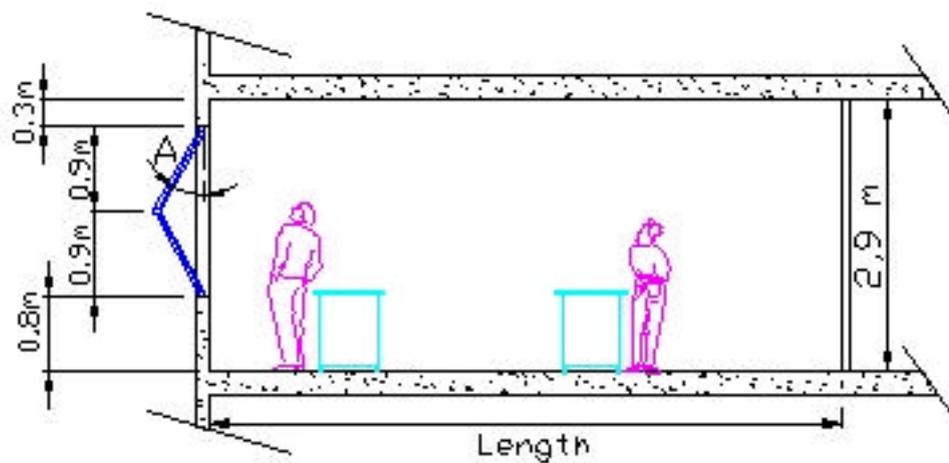


Fig. 9 Geometry of the test room.

Lightscape simulation software was also adapted in order to consider input from virtual goniophotometry. Several parameters were checked, either depending on outdoor illumination and conditions (15 CIE Standard Skies, ground or not, obstructions or not), or depending on the room itself (Length, and inclination of the tiltable panels). The pictures below (Fig. 10 & 11) show only a very small part of such results, were for example illuminance levels deep inside the room are increased by a factor of almost 3 (Fig. 12).

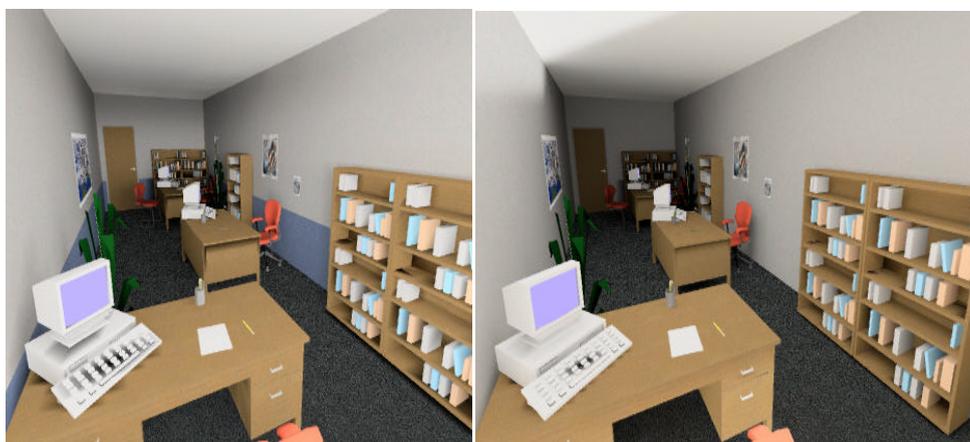


Fig. 10 Daylighting simulation of simple glazing (left) and Serraglaze (right) – Views from the window.



Fig. 11 Daylighting simulation of simple glazing (left) and Serraglaze (right) – Opposite views.

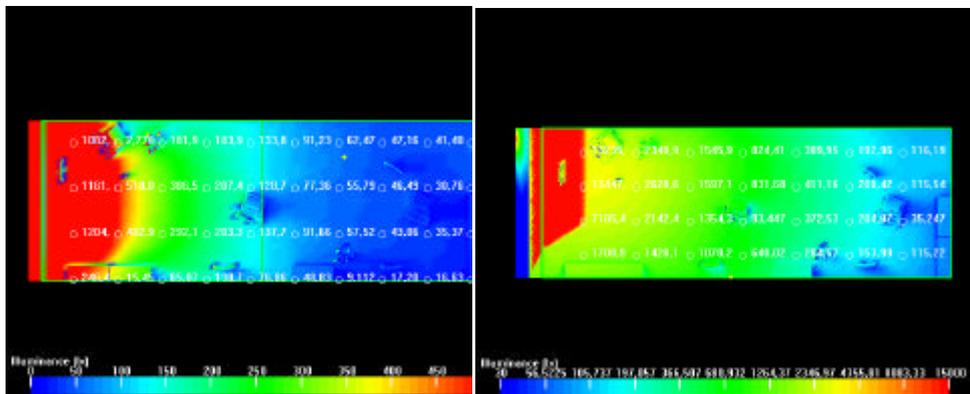


Fig. 12 Daylighting simulation of simple glazing (left) and Serraglaze (right) – Illuminance levels.

Real case study setup : daylighting within the TwinCells

In order to validate simulation results, a real case study has just started, and based on full 1:1 scale experiment within the TwinCells (IEA SHC Task 21), where the left room is equipped with tiltable Serraglaze product, and compared with the right reference room (Fig. 13).



Fig. 13 Real 1:1 scale experiment within the TwinCells (right). Left Room is equipped with tiltable Serraglaze window (left).

Observed quantities include outdoor and indoor luminances and illuminances, with input from calibrated digital photography and cells measuring illuminance levels. Luminance field of view study should also lead to glare parameters analysis.

Unfortunately, due to the early stage of the experimental setup, no results are yet available. However, in order to compare simulation with experimental results, we also now need to change the geometry of the test room to the geometry of the TwinCells.

Conclusion

It is now possible to characterize and analyse the daylighting performance of daylighting components, either in situation with adapted daylighting simulation, or globally, by mean of source-like equivalent distribution that can be obtained by mean of virtual goniophotometry. However, such an approach and associated software components and applications still need to be validated by mean of real full-scale experiments. On the other hand, it is clear that experimentally measured photometries have also a big role to play within the virtual goniophotometry approach, were the system response needs to be characterized prior any daylighting simulation. This would also be the challenge of future works.