Designing a Solar Shading Solution Parametrically using the Direct Sun and the View to the Outside for a Building in Ho Chi Minh City, Vietnam

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Abstract
In this case study in Ho Chi Minh, Vietnam, the architectural design featured a passive shading element, following a pattern of vertical elements with varying depth, width, and thickness. Using state-of-the-art assessment tools, the performance of the element was to be assessed and optimized. The main challenge was to build a highly responsive solution: if the feedback loop of the façade analysis is slow, it would not follow the architectural changes during concept phase and the analysis would lag behind the experiments of the design team.

At first, it was decided to use dynamic daylight simulations using Radiance engine so that the façade design could be studied in detail. This approach was deemed unfit as optimized results would take away the view to the outside, which was one of the key assets of the design (Figure 2).

Hence a different approach was necessary. Instead of using one global metric for daylight, two static calculations were introduced in the parametric script: the direct sun penetration and the view to the outside. This approach proved more effective and faster than the first one. The extra time allowed to test more cases, and to optimize each piece of the façade based on its orientation. A dynamic daylight simulation confirmed the efficiency of the final proposed façade.

Key Innovations
- Alternative method for passive design for climates where the solar gains represent a permanently undesired cooling load.

Introduction
The case study is an 18-storey high mixed-use tower in Ho Chi Minh City, Vietnam. Half of the tower is office space, and the other half is luxury residential. The façade runs through all the storeys, hence the study examines both occupation types.

Figures 1: Preliminary design of the building’s façade.

The goal of this project was to design a passive façade in a quick and responsive manner, such that it could react to the pacey rhythm of the architectural design. Local regulation does not require or recommend any daylight standards. LEED requirements were used for benchmarking purposes.

At this phase, thermal dynamic simulations were avoided: it would be too time-consuming to set up such a model and keep it updated; the details of the façade would need to be simplified; the conditions of building usage were unknown. Hence the design team considered the use of daylight metrics for the assessment. In hot and humid climates, solar gains are a permanent cooling load, therefore controlled daylight levels are a great asset for the building energetic performance.

The parametrization was set up using Rhino and a Grasshopper script. The first attempt for such evaluation used the Useful Daylight Autonomy (UDI) calculation for all the indoor spaces as metric, with thresholds of 100 and 2000 lux[1], using Radiance as calculation engine.

Parametric properties were assigned to the shading elements, and hundreds of possibilities were calculated using the UDI in a sample space, after which the results were trimmed manually.

The conclusions were presented to the design team. The exercise proved unfruitful as calculations were slow and did not address the design team concerns – maximizing the view to the outside. Figure 2 highlights the issue: the Useful Daylight Illuminance was optimized by increasing the number of blades up to a point where the external view was eliminated, leaving only diffuse light entering the building.

Figure 2: Useful Daylight Illuminance results were optimized once the view to the outside is eliminated.

Given that:

a) Simple Radiance-based calculations are time-consuming (can take 10 minutes for a small box)

b) The optimization of the building façade disregarded the view to the outside.

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A new method had to be found to design the façade of this building.

**Method**

Instead of one global daylight metric, two static calculations were introduced in the grasshopper parametric script:

1. **Direct sun penetration (%)** – the number of rays going through the shading and entering the building.
2. **View to Outside (%)** – similar approach, fixing the position of the building occupant and shooting rays in a 90° angle towards outside. Ten locations were selected inside the building for this assessment, at a fixed distance from the glazing.

*Figures 3 and 4: Visual representation of the direct sun penetration (left) and view to outside (right).*

The sun location has been selected following LEED visual comfort requirements: 9 am and 3 pm.

The implementation of this method opposed to the Daylight Autonomy brought a lot of benefits to the analysis:

- The façade could be changed during team meetings, with results available in seconds.
- Using simple calculations, the speed was greatly enhanced, meaning that the parametric analysis could test more possibilities.
- This method ignores the properties of the glazing, which were unknown at this stage – Radiance-based would require further scenarios with different glazing properties.

3,000 solutions were evaluated with the new approach using an automated script. Although the simulations were rather fast, it could still take up to 30 seconds per case (25 hours for all the cases). If using any radiance-based metric at an acceptable resolution (20 minutes per simulation), one would be able to run only 70 variants within that timeframe. Graphing the results using two axes, it became straightforward to identify the best results: minimum direct sun and maximum view factor (Figure 4).

*Figure 4: Low-hanging fruits of the 3,000 calculation results.*

The new approach and the array of best cases were then presented to the design team. It was now in the hands of the design team to implement the correct balance of performance and aesthetics into the final design.

Upon redesign, the final step was then to verify whether the selected façade had been improved based on the UDI of the initial design from the architect.

**Results**

The last step of this was to reassess the final façade using the UDI metric. From the initial proposed design to the improved design, the UDI was increased from 72% to 83%. The results below clearly show the success of the design, where only the unprotected balcony was harming the visual comfort indoors, and the daylight is in balance.

*Figure 5: UDI for the office floor.*

**Conclusion**

Daylight simulations can be extremely helpful for passive design. These are easier to set up than thermal simulations and require less inputs. However, using this method combined with parametric design might hinder the true design potential, as accurate simulations will take a serious amount of time to perform. Therefore, the development of other alternative creative solutions, such as the one proposed here, could come in help to speed up the analysis during a parametric optimization. Daylight simulations could then be done only for the best cases.

**References**