DESIGNING A HIGH PERFORMANCE FACADE IN 5 STEPS

How architects can leverage existing design decisions to achieve a high performance facade
What Makes a Good Facade?

What makes a good facade or building skin? In architectural terms, it is an opportunity for designers to express their design vision and aesthetic intent. As the interface between inside and outside, it has tremendous implications for climate regulation, daylight levels, energy consumption and the building’s overall carbon intensity. So how do designers approach the design of facades to ensure success on all fronts?

Creating a high performing facade is a balancing act that usually involves three performance goals: maintaining good daylight levels, minimizing glare, and reducing energy use. In this eBook, we outline 5 steps to optimising your facade designs via design decisions such as glazing ratios, material specification, and shading. We illustrate each step using an example Part L baseline building located in a London infill site with east and west party walls.

North and south view of the proposal set within a typical London urban block
5 Steps to an Optimised Building Envelope

1. Understand your building’s energy profile
2. Find the best glazing ratio & location
3. Investigate shading
4. Investigate materiality
5. Design & iterate
Understand Your Building's Energy Profile

To start off, it is important that you understand your building in context, i.e. the overall impact of surrounding buildings, shared boundary walls, local weather and building use on the building’s performance. Running initial analysis on your modelled building reveals what energy loads are problematic in your building and what issues are most important to tackle -- a high heating load would suggest that you focus on strategies that reduce heat loss, such as air tightness or insulation levels.

Using a rough preliminary model, we found that our design was cooling dominated. Design decisions that could improve performance include glazing ratios, glazing specifications such as Solar Heat Gain Coefficient, and natural ventilation.
Find the Best Glazing Ratio & Location

One of the key markers of a successful facade is specifying the right amount of glazing, not only for aesthetic reasons, but to harness daylight where possible and intelligently manage solar gains. The crucial metrics for determining this are daylighting metrics* such as Spatial Daylight Autonomy (sDA) or Daylight Factor (DF), Annual Sunlight Exposure (ASE) (a proxy for glare), and energy metrics such as Energy Use Intensity (EUI). The ideal design would have sufficient illuminance, low glare and low energy use.

In our analysis, we tested equal glazing ratios on both north and south facades then alternated high and low figures on either facade. We got higher levels of unfavourable glare when more glazing was placed on the south facade. Interestingly, this option also offered almost double the illuminance compared to the north glazing.

In this scenario we selected the option with more south glazing because of the higher illuminance levels. By choosing this option we know that the trade-offs are higher glare and EUI value. Our design will need to address them by possibly

FURTHER READING
*See these articles to learn more about daylight metrics:
  Slideshare: Visualising Daylight Factor & Illuminance Levels
  Blog Post: Measuring Daylight: Dynamic Daylighting Metrics & What They Mean for Designers
  Webinar: Sefaira Daylight Webinar
Investigate Shading

In most projects, it is particularly important to align the shading strategy with the architectural intent. Considering the busy street context of our building, the design intention was to present a civic and restrained facade to the city. To tackle glare and unwanted heat gain, we tested shading devices like horizontal and vertical projections or brise soleils - noting that each option has very particular implications for our aesthetics.

Our three options were:
- horizontal projections at the top of the glazed opening
- horizontal brise soleils running down the glazed surface
- slatted horizontal projections at the top of the glazed opening.

Comparing the best three options from each shading type, we opted for the slatted horizontal projection. This is because it sits well with our design intent and also offers the best trade-off between energy and daylight.

<table>
<thead>
<tr>
<th>FINAL SELECTION</th>
<th>DEPTH</th>
<th>SEPARATION</th>
<th>EUI</th>
<th>sDA</th>
<th>ASE</th>
<th>% Diff</th>
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</thead>
<tbody>
<tr>
<td>horizontal projections at the top of the glazed opening</td>
<td>0.50cm</td>
<td>N/A</td>
<td>99</td>
<td>65%</td>
<td>18%</td>
<td>47%</td>
</tr>
<tr>
<td>horizontal brise soleils running down the glazed surface</td>
<td>20cm</td>
<td>15cm</td>
<td>102</td>
<td>61%</td>
<td>16%</td>
<td>45%</td>
</tr>
<tr>
<td>slatted horizontal projections at the top of the glazed opening</td>
<td>2.44m</td>
<td>25cm</td>
<td>102</td>
<td>57%</td>
<td>13%</td>
<td>44%</td>
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</table>
Investigate Materiality

The aim at this stage is to retain our great daylight levels and low glare but further reduce Energy Use Intensity by specifying appropriate materials. Decisions ranging from building materials to wall thickness, construction type, and cladding solutions can have a significant impact on the building’s overall performance.

We tested a number of properties to help inform the design and specification of our facade, including wall insulation, thermal mass, openable glazing, glazing u-value and SHGC, and infiltration. In our scenario, we discovered the following:

Glazing

- Improving the glazing U-value offered little or no EUI improvement (<1%).
- Improving the glazing Solar Heat Gain Coefficient (SHGC) reduced our overall cooling loads by 28% making it a strategy worth considering -- lower cooling loads mean a smaller, cheaper HVAC system and lower utility costs.
- Combing U value and SHGC strategies balanced out unwanted increases in cooling and heating, offering a better reduction on cooling (26%) and a minimal increase in heating loads (3%).
More importantly, it turned out that introducing a natural ventilation strategy offered far greater benefits than improving glazing specifications. Seeing as our long slim plan did not lend itself to single-sided or cross ventilation, we opted for a stack ventilation strategy. Cutting a well in the plan in the darkest area of the plan would create interesting spatial connections between the different floors, improve daylight and serve our stack ventilation strategy.

Walls

- Analysing material options for walls (brick, concrete block, stud, precast concrete, curtain and Exterior Insulation Finishing System) revealed that high thermal mass options such as brick or concrete performed best in Annual Energy Consumption, EUI and CO2 production terms.
- A mix of both brick and concrete offered the right contrast in texture. We were able to express our design intent and achieve high performance in energy terms.

From these tests we were able understand that natural ventilation and thermal mass were the crucial factors for our design -- simply insulating over code values offered far less benefit.

Our walls will have to be made from dense materials and be of a considerable thickness to contribute towards thermal mass.
Design & Iterate

Having analysed a range of factors, we have discovered that some are more important than others. By combining the best glazing ratio, shading, and a heavy structure, overall we were able to achieve:

- A reduction in EUI from 102kWh/m² or 32KBTU/ft² (original Part L baseline) to 61kWh/m² or 19KBTU/ft² - also meaning we fell well under the Architecture 2030 target of 105.
- A massive 74% reduction in cooling load and therefore a smaller, cheaper HVAC system.
- 27% reduction in both CO2 production and utility costs.

As we continue to design, we can continue to use performance feedback to inform our design decisions — ensuring that our final design performs beautifully.

<table>
<thead>
<tr>
<th>MASSING OPTION</th>
<th>SHADING DEPTH</th>
<th>ANNUAL ENERGY</th>
<th>EUI kWh/m²</th>
<th>xDA</th>
<th>ASE</th>
<th>HEATING kWh</th>
<th>COOLING kWh</th>
<th>CO2 kgCO₂</th>
<th>UTILITY COST £</th>
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<tr>
<td>BASELINE</td>
<td>0.50m</td>
<td>161,468 kWh</td>
<td>102</td>
<td>65%</td>
<td>18%</td>
<td>13183 kWh</td>
<td>47255 kWh</td>
<td>84207</td>
<td>£35,674</td>
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<td>OPTIMISED ENVELOPE</td>
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<td>122,658 kWh</td>
<td>61</td>
<td>65%</td>
<td>18%</td>
<td>14641 kWh</td>
<td>12326 kWh</td>
<td>61557</td>
<td>£28,011</td>
</tr>
<tr>
<td>% DIFFERENTIAL</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>▲11%</td>
<td>▼74%</td>
<td>▼27%</td>
<td>▼27%</td>
</tr>
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By testing their intuition, rules of thumb and assumptions, architects can clearly understand the tradeoffs between their design decisions and the building’s performance. Armed with this data, decisions about facade design -- glazing ratios, material specification, thermal mass and shading -- can be made with a combination of robust data and creativity.
How Sefaira Can Help

Sefaira makes sustainability analysis a seamless, integral part of the design process. It is specifically tailored to help architects make design decisions while a design is still evolving.

Sefaira’s industry-leading Real Time Analysis and powerful parametric analysis capabilities make it easy to do the types of comparisons and optimizations described above.

About Sefaira

Sefaira was founded in 2009 with a mission to promote more sustainable buildings by helping the building industry design, build, operate, maintain and transform all facets of the built environment.

Our applications are based on deep expertise in combining building physics and computer science, and this unique expertise has enabled us to be the first and only company able to provide true real-time physics based analysis to the global building design community.

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Sefaira allows architects to perform more analysis, more frequently, and at lower cost, helping to set projects on the right trajectory and ultimately delivering better-performing, more sustainable buildings.