SHC 2012

Cooling demand and daylight in the new Tallinn Town Hall buildings the influence of facade design

Hendrik Voll¹, Erkki Seinre

¹Tallinn University of Technology, Ehitajate tee 5, Tallinn 19086, Estonia

Abstract

The site of the new Tallinn Town Hall designed by the BIG architects is situated to the north of the medieval city center on the edge of the green ring close to the waterfront. The goal is to create a new urban typology that combines the human scale and intimate experience of the medieval townscape, with the public space and municipal symbolism of the modern extension. The New Town Hall will be an open and permeable public institution, extending both town center and the green ring all the way to the water’s edge. The building will be created of a village of ten individual departments and two for common space and meeting rooms. Each department is accommodated in its own dedicated office building. A thirteenth building, the tower hosts the City Government, the City Council and the Council Hall on the top floor. The departments are grouped together to meet the programmatic requirements of adjacencies. The departments are consolidated in a village-like cluster, allowing them to perform as a single open office structure as well as ten independent departments. The departments are hinged on the corners and rotated to leave courtyards for daylight and views between them. The many generous openings also provide views to the public ground floor below as well as the sky above. The current paper gives an overview of the daylight modeling and facade design, describes passive architectural cooling strategies considered. Estonia is situated in latitude 59° which means that the solar angle of incidence is rather low from late autumn to early spring. The maximum solar angle of incident is just 7° in December 21st. Then at the other side the summer temperatures are of average 27 °C which makes the shading strategies essential. The building is currently in detail design phase and the construction work will presumably start in early 2014. The building has been already shortlisted for a World Architecture Festival Award in the Future Projects and Competition entries category.

Keywords: Façade design; solar architecture; passive cooling

1. Tallinn Town Hall building

The site area is approximately 12,000 m² and the new administrative building will be approx. 26,000m². The building will be created of a village of ten individual departments and two for common
space and meeting rooms. Each department is accommodated in its own dedicated office building. Figure 1 shows the building organization and layout and figure 2 the planned building outlook.

Fig. 1. The layout of Tallinn Town Hall Building by BIG architects

Fig. 2. The outlook of planned Tallinn Town Hall Building by BIG architects
A thirteenth building, the tower hosts the City Government, the City Council and the Council Hall on the top floor. Figure three presents the Town Hall. The tall building in front of the figure is the City Government facing the south orientation.

As can be seen from the figure 3 the planned building has majority of its façade covered with glass which makes the daylight design challenging.

1.1. Daylight

Daylighting of buildings by using the diffuse rays of the sunlight as the primary light source has been given a great deal of research attention in the last 15 to 20 years. Studies by [1] or [2] or [3] showed the positive effects of daylight on students, shoppers and office workers health and productivity. According to [4] or [5] daylit buildings seem to increase human performance, partly because people enjoy such spaces and will stay a little longer and return more frequently to their work place or, when shopping, to the shop. The main objective of this paper is to show the modeling results for diffuse daylight and direct sun and discuss the challenges the design team is facing in regards of good daylight design.

Good quality daylight should be sufficient for visual tasks, visually comfortable and perceptually pleasing, glare-free, and well distributed across the space. In other words the daylight is a combination of diffuse daylight and direct solar radiation. Based on [6] Estonian Standard 894, *Daylight in Dwellings*, it is
the daylight factor that describes diffuse daylight. In general, the daylight factor is the ratio of inside illuminance to outside illuminance at a specific point, expressed as a percentage.

\[ DF = 100 \times \left( \frac{E_{in}}{E_{out}} \right) \]  

where

- \( DF \); The daylight factor, [%],
- \( E_{in} \); Inside illuminance at a fixed point, [lx],
- \( E_{out} \); Outside horizontal illuminance under an overcast sky, [lx].

In north European circumstances, spaces with average daylight factor of 1.5 are normally considered to give the room’s occupant the feeling of a daylit room.

Glare is defined as difficulty seeing in the presence of bright light that may be caused by either direct or indirect viewing of a light source (O’Connor 1998). Direct glare is caused by light coming directly to the eye from a light source. Indirect glare is light reflected from a surface in the direction of the eye. Both can harm vision and cause visual discomfort or disability. Here, from direct sunlight reflecting off a glass surface is investigated.

1.2. Diffuse daylight analysis

The proposed New Administrative Building, Tallinn has been modeled by Ramboll UK using Integrated Environmental Solutions Virtual Environment (IESVE) Fluc DL to analyse compliance with EVS 894 Daylight in Dwellings and Offices [7]. To demonstrate daylight levels throughout the building, calculations have been carried out across Level 02. As required by EVS 894, the daylight calculations have been analysed according to the following:

- The minimum daylight factor within the space.
- The average daylight factor within the space.
- The uniformity factor of each space. The ratio of the minimum daylight factor to the average daylight factor should be between 0.3 and 0.5.
- The daylight factor at the point in the middle of the room at work surface height 1 m from the back wall should not be smaller than 1%.
- The daylight factor on workplaces. As many workplaces as possible should have a minimum daylight factor of 2% in the work zone, with all workplaces having a minimum daylight factor of 1%.

Table 1 indicates the overall diffuse daylight results for the new Tallinn Town Hall building.
Table 1. An example of a table

<table>
<thead>
<tr>
<th>Level 02 daylight results</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum daylight factor</td>
<td>0,1%</td>
</tr>
<tr>
<td>Area Weighted Average Daylight Factor</td>
<td>3,0%</td>
</tr>
<tr>
<td>Area Weighted Uniformity Factor</td>
<td>0,03</td>
</tr>
<tr>
<td>Total number of workplaces</td>
<td>331</td>
</tr>
<tr>
<td>Number of Workplaces with Daylight F. &gt; 2%</td>
<td>128</td>
</tr>
<tr>
<td>Number of Workplaces with Daylight F 1–2%</td>
<td>53</td>
</tr>
<tr>
<td>Number of Workplaces with Daylight F. &lt; 1%</td>
<td>150</td>
</tr>
</tbody>
</table>

The average daylight factor across Level 02 indicates a high level of absolute daylight exceeding the minimum level. However, the uniformity of daylight throughout the building is not within the levels recommended by EVS 894. The extremely high levels of daylight in areas adjacent to the facades and atria, combined with the deep plan of the boxes, results in poor levels of uniformity. 181 workspaces across Level 02, equivalent to 54%, will receive a daylight factor exceeding the required 1%. Furthermore, 128 of will receive the recommended higher level of 2% daylight factor, equivalent to 39% of the total workplaces.

1.3 Direct sunlight analysis

The most challenging part of the façade design is how to prevent glare by blocking the direct solar access. It was the BIG architects demand that no external shading shall be used. So the only options acceptable were lamella system between the glazing or inside the room. Lamella system was presented by the design team according to right figure 4. The concept introduced that when the solar angle of incident is 60° lamellas are in open position and no view is obstructed. When solar angle of incident is 40° about 50% of the view is obstructed and only when solar angle of incident is 20° or below all the view is obstructed by the lamellas.

Tallinn, the capital of Estonia is situated in a latitude 59,2° which means that the maximum solar angle of incident occurs on June 21 and is about 54°. On April 21 and August 21the daily maximum solar angle of incident is about 43°. That means that in a theoretical situation where there will be sunny autumn, winter and spring the lamellas would be closed in a way that there will be no view to the outside. Translucent lamellas were considered as well unfortunately there is no manufacturer in Europe who could still provide such a lamella system.

The design project is currently in a detailed design phase and the design team is desperately looking for the alternatives for the lamella system. The most probable replacement system could be automated translucent curtains as also shown on left figure nr 4.
1.4 Conclusion and discussion

The site of the new Tallinn Town Hall designed by the BIG architects is situated to the north of the medieval city close to the waterfront. The building will be created of a village of ten individual departments and two for common space and meeting rooms. Each department is accommodated in its own dedicated office building. A thirteenth building, the tower hosts the City Government, the City Council and the Council Hall on the top floor. The departments are consolidated in a village-like cluster, allowing them to perform as a single open office structure as well as ten independent departments. The departments are hinged on the corners and rotated to leave courtyards for daylight and views between them. The many generous openings also provide views to the public ground floor below as well as the sky above. The departments have large windows providing panoramic views in all directions. The current paper gives an overview of the daylight modeling and facade design, describes shading strategies considered. Estonia is situated in latitude 59° which means that the solar angle of incidence is rather low from late autumn to early spring. The maximum solar angle of incidence is just 7° in December 21st. The article introduced the problem in finding the proper solution for preventing the glare from the direct solar radiation.
Acknowledgements

The present work was supported by EU Social Fund project number MOJD 107.

References