Visual Comfort in Traditional Buildings of the 19th Century in North-Western Greece. 
The Case of Florina

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ABSTRACT: The aim of this paper is to explore the daylighting conditions in traditional buildings of the 19th Century in the city of Florina located in North-western Greece, using a sample of various typical houses. The study of the visual comfort in the spaces of these traditional buildings is based on an analysis using software tools. This analysis concerns the calculation of daylighting levels in the ground floor and in the upper storey with overcast sky conditions, and the simulation of daylight distribution in specific rooms on both levels, with clear sky conditions. The paper is part of an ongoing Ph.D. thesis with title: “Exploration of the environmental performance of traditional buildings in Western Macedonia focusing on the area of Florina”, and constitutes an overview of issues, which are related to visual comfort using daylighting analysis simulation software.

Conference Topic: 8 Traditional solutions in sustainable perspective
Keywords: traditional architecture, NW Greece, daylighting, visual comfort

INTRODUCTION

At a large extent, traditional buildings of the 19th Century in North-western Greece are oriented in such a way as to achieve the best possible exploitation of daylight in their living spaces. The large number of windows in the summer closed (odas) or semi-open spaces (doxatos) aim at the visual comfort of the users. Architectural elements, such as enclosed open spaces (hayat) and projections (sahnisi) constitute an evolution of the open sunspace (helikos or liakotos) and are characteristic examples of using the sun as a light source for the visual comfort of users.

2. DESIGN ANALYSIS OF TRADITIONAL BUILDINGS

2.1 Orientation Analysis

The city of Florina is situated in a mountain valley, which is crossed by a river from West to East. The main streets of Florina run from West to East and are parallel to the river. As a result, most of the houses face either north or south, depending on the side of the river they are on. At the same time, some houses, which are situated in the interior of urban blocks, and on the perpendicular, secondary streets, face mainly east. From a sample of 34 remaining traditional houses, 11 have northern orientation, 14 southern, 7 eastern, and only 2 are west orientated.

2.2 Building Typology

According to the typology of traditional buildings of Florina (Fig. 1), the main living spaces have three openings orientated towards the south. If a house is orientated towards the north, the same morphology is applied, but there is also a care for openings with southern orientation. In the larger houses (arhontika), there are also eastern and western openings. As a result, in a large house, a summer main living space (odas) with a square plan can have up to six openings in the two sides. When the upper floor projects over the ground floor (sahnisi), there is also a smaller window in the third side. This smaller opening helps the cross-ventilation of the space, but its main function is to watch over the street.

Figure 1: Building typology.

The semi-open spaces (hayat) are orientated towards the south or, in some cases, the north. In the second instance, openings exist in the south wall of
the *hayat* in order to increase the direct solar gains and the daylight in the interior of the house. The *hayats* have a quadrangular shape in the older houses and are completely open in their one side. In the latest types, where the building plan has a more urban character, the *hayats* decrease, become narrower and function only as circulation spaces.

In many cases, openings are constructed in the interior walls of the living spaces facing towards the *hayat*. In this way, the daylight levels in the living spaces are increased because of the additional diffuse light. When the *hayat* is originally designed as, or is transformed to, a closed space, the outer wall has three windows, similar to the living spaces. There is also the possibility of projecting the semi-open space outside the ground floor outline. In this case, the space, which is created, can have up to nine windows (three in every orientation). At the same time, its internal wall has up to three windows, in order to obtain sufficient daylight in the staircase area.

### 3. VISUAL COMFORT

#### 3.1 Daylighting Modelling

The daylighting analysis calculations were performed with the software Ecotect v5.2 [1] (Fig. 2). First, the model of a representative building type was constructed. Second, the model was modified in order to represent three variations based on existing examples, with differences in the orientation and the openings. These variations included a house with northern orientation, one with eastern orientation, and one with southern orientation, which are referred from now on as N House, E House and S House, respectively. It must be noted that the E House and the S House are free-standing, whereas the N House shares a party wall on its south side (Fig. 3-7).

![Figure 2: 3D model constructed with Ecotect. [1]](image)

![Figure 3: N House, before the restoration.](image)

![Figure 4: N House, after the restoration.](image)

![Figure 5: E House, view from the north-east.](image)

![Figure 6: E House, view from the south-east.](image)

![Figure 7: S House, view from the south.](image)

The daylighting analysis was performed with the software Ecotect v5.2 [1]. The calculations were based on the CIE overcast design sky, and the sky illuminance values were defined according to [2] (Table I). The working plane for both the ground and the upper was assumed at 800 cm from the floor. The isolux contours had a range from 100 lux to 1100 lux, with a step of 100 lux.
Table I: Sky illuminance values (lux), which were assumed for the calculations.

<table>
<thead>
<tr>
<th>Month</th>
<th>09:00</th>
<th>12:00</th>
<th>15:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEC</td>
<td>4500</td>
<td>8500</td>
<td>4500</td>
</tr>
<tr>
<td>MAR</td>
<td>11000</td>
<td>17500</td>
<td>11000</td>
</tr>
<tr>
<td>JUN</td>
<td>18250</td>
<td>32500</td>
<td>18250</td>
</tr>
</tbody>
</table>

The results from the daylighting analysis with Ecotect are based on overcast sky. As a result, they only give an indicative image of the daylight distribution and the illuminance levels in the spaces of the houses, which were modelled. This indicative image corresponds to the worst-case scenario, and does not take into account any direct sunlight, which falls into the spaces with clear-sky conditions.

In order to obtain a more complete idea concerning the daylighting conditions in the main winter and summer living spaces, Ecotect [1] was used in order to generate rendered images with the Radiance software [3]. The ground floor was used during the winter. For this reason, the ground floor main living space was simulated with clear sky conditions for three hours (09:00, 12:00 and 15:00 TST) on December 21st, and with overcast sky conditions for 12:00 of the same day. The upper storey was used during the intermediate seasons and the summer. The main living space was thus simulated with clear sky conditions for three hours (09:00, 12:00 and 15:00 TST) on March 21st and on June 21st.

3.2 Analysis of Lighting Conditions. Winter Visual Comfort

The ground floor of N House is very dark because of the few and small openings, and the orientation of the house. Only restricted areas, which are found in the immediate vicinity of the windows, have sufficient daylight, whereas the majority of both primary and secondary living spaces are completely deprived of natural light (less than 100 lux) (Fig. 8). This fact was also evident from the Radiance simulations, where the ground floor main living room appears particularly dark, with only few hours of direct sunlight, when the sky is clear (Fig. 9).

Both the main living spaces of the ground floor of E House have sufficient daylighting. The south-eastern main room has optimised daylighting conditions, due to the presence of three openings on the eastern and two on the southern wall. The secondary, back rooms and the central circulation space have relatively poor daylight, and only the areas, which are very close to the windows, have sufficient light (Fig. 10). The Radiance simulations in the south-eastern main room demonstrate that daylighting levels and distribution are very good, despite the dark colour (sea blue) of the walls. This fact is due to the south-east orientation and the presence of many openings. Furthermore, there is direct incident sunlight throughout the day (Fig. 11).
At the ground floor of the S House, the openings on the main, southern facade contribute to the penetration of sunlight into both main living spaces, and the central circulation space. Nearly two thirds of the area of these spaces have daylighting values of over 300 lux, with overcast sky conditions. On the contrary, the daylighting analysis showed that the northern spaces are completely deprived of natural light, because of the absence of windows, apart from a small opening in the north-eastern room (Fig. 12). The Radiance analysis showed that the daylighting levels in the main winter living space are sufficient. There is direct sunlight coming from the southern openings until noon (Fig. 14).

The S House was also modelled for its most probable original state, namely with an open common space (hayat) on the ground floor (Fig. 13). The daylighting analysis showed that the open hayat considerably improved lighting levels, not only in the semi-open space, but also, through interior windows on the hayat walls, in the main winter living spaces. This open space was used throughout the year for household tasks.

3.3 Analysis of Lighting Conditions. Summer Visual Comfort

The primary living spaces and central area of the upper floor of N House have many windows on the northern facade. Furthermore, there are windows on the eastern and western walls. As a result, the main spaces have sufficient light, even with overcast sky conditions. On the other hand, the staircase area has poor lighting conditions, because of the scarcity of openings. Each secondary room has three openings on the eastern and western wall, respectively. These openings bring sunlight into the rooms, and mainly help improve lighting conditions near the window area (Fig. 15). The Radiance simulations demonstrate that the main summer living space is characterised by optimised visual comfort conditions throughout the summer, as well as the intermediate seasons (Fig. 16).
The upper floor of the E House has an increased number of openings on both the eastern and the southern facades. As a result, daylight distribution levels in both primary living areas, the central area and the south-western secondary room is very good (Fig. 17). The north-eastern main room has sufficient daylight, especially near the zone of the windows. The only dark space is the north-western secondary room, which has two, relatively small openings. Similar to the ground floor Radiance simulations, the visual comfort in the upper storey, main living room appears to be satisfactory, in spite of the dark colour (Fig. 18). There is incident sunlight from the openings during the intermediate seasons, whereas during the summer, the south openings are completely shaded by the eaves of the roof.

Figure 17: E House, upper floor daylighting analysis. [1]

Figure 18: E House, upper floor main living space daylighting simulation (21/06, 09:00, clear sky). [3]

The openings of both the ground and the upper floor of the S House are very similar in size and in design. There are no additional openings on the eastern and the western walls of the main living rooms of the upper storey. As a result, the distribution of natural light on both levels is almost the same, i.e. two thirds of both living spaces and the central area have over 300 lux (Fig. 19). Each one of the two secondary rooms has a window in the eastern and western wall, respectively, which slightly raises daylighting levels. The Radiance simulation for the upper storey, main living room demonstrates that the space has improved daylighting conditions (Fig. 20). There is incident sunlight from the openings during the intermediate seasons. On the contrary, the eaves of the roof completely shade the southern openings during the summer noon, and the space has only diffuse daylight.

Figure 19: S House, upper floor daylighting analysis. [1]

Figure 20: S House, upper floor main living space daylighting simulation (21/06, 09:00, clear sky). [3]

3.4 Comparison of Different Orientations and Design of Windows

In the case of the ground floor of the E House, the opening of windows on the southern wall for aesthetic and, most probably, (bio)climatic purposes, has a very positive contribution to the daylighting conditions, which prevail inside the main winter rooms. The S House is characterised by slightly worse daylighting conditions on the ground floor, mainly because of the openings, which are restricted in the south facade that coincides with the main street facade. On the other hand, the scarcity of openings in the case of the N House ground floor probably means that thermal comfort in the winter living spaces was far more important than visual comfort. While there is a possibility that original eastern openings were at a later stage built up, it is not surprising that the house with the worst daylighting conditions is actually the one with the most unfavourable orientation. In any case, the restoration of the N House included the opening of several windows on the eastern wall of the ground floor.

As was the case in the ground floor, the creation of southern windows in the upper storey of the E House, in addition to the eastern ones of the main facade significantly improves daylighting conditions in all living spaces with southern and eastern
orientation. The N House has slightly lower daylighting levels. In this case, the compactness of the ground floor is completely reversed on the upper storey, where both the living spaces have three openings on each of the two outside walls. Three additional windows are also created on the eastern and western walls of the secondary rooms, thus contributing to their sufficient daylighting. Finally, the S House has the poorest daylighting conditions, compared to the other two houses. This is caused by the fact that the southern windows of the ground floor are maintained in the upper storey with the addition of only two windows on the eastern and western wall of the main living spaces, respectively. In any case, the upper storey main spaces of the S House have sufficient daylight throughout the year, due to the favourable orientation.

Table II: Comparative matrix of daylighting levels (lux) with overcast sky conditions (Ecotect analysis [1]).

<table>
<thead>
<tr>
<th>Floor Spaces</th>
<th>N House</th>
<th>E House</th>
<th>S House</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Primary</td>
<td>&lt;100</td>
<td>&gt;300</td>
<td>&gt;300</td>
</tr>
<tr>
<td>2ndary</td>
<td>&lt;100</td>
<td>100-300</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Upper Primary</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>&gt;300</td>
</tr>
<tr>
<td>2ndary</td>
<td>100-300</td>
<td>100-300</td>
<td>&lt;100</td>
</tr>
</tbody>
</table>

Table III: Comparative matrix of daylighting conditions (qualitative evaluation) with clear sky conditions (Radiance simulations [3]).

<table>
<thead>
<tr>
<th>Floor Spaces</th>
<th>N House</th>
<th>E House</th>
<th>S House</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Primary</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Upper Primary</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

CONCLUSION

This paper clearly demonstrates that the traditional architecture of north-western Greece took into consideration matters of orientation, daylighting and visual comfort. In the case of the favourable - southern- orientation, a large number of windows existed on the main facade on both levels. On the contrary, when the houses are north orientated, the ground floor, which constitutes the winter living space, has relatively few windows. Finally, in the case of houses with eastern orientation, there are many openings not only on the eastern, main facade, but also on the southern one. From the above, it becomes clear that the design of traditional houses in Florina was not only formed by the orientation, but also by the specific climatic conditions, which prevailed in the area during the harsh, cold winter and the warm, dry summer.

Finally, this preliminary study of the daylighting conditions in traditional buildings of Florina revealed the need for a full-scale and multi-levelled investigation. It was realised that there is need for more detailed daylighting simulations, as well as for in-situ daylighting measurements in a selection of the remaining houses.

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REFERENCES