A STUDY ON INTERIOR LIGHT ENVIRONMENT IN JAPANESE TEAHOUSE AND ITS RELATION WITH TEA CEREMONY

U KEISEN¹, HARUYUKI FUJI² and YUKI KOBAYASHI³

¹,² Tokyo Institute of Technology
¹,² {yu.j.ag|fujii.h.aa}@m.titech.ac.jp
³ Osaka City University
³ kobayashi@osaka-cu.ac.jp

Abstract. The lighting of a traditional Japanese tea house mainly relies on natural light introduced through the windows. The light environment is designed very skillfully under influence of both functional consideration and tea ceremony ideology. In order to explore the relation between the lighting strategy and tea ceremony, the paper proposed and examined a new way to study the traditional tea house daylight environment by using CAD and daylight simulation tool. Through the investigation of the daylight environment in various tea houses, the study gained more understanding of how the light environment is composed under the influences of tea house designers and tea ceremony ritual.

Keywords. Traditional; Cultural; Tea House; Daylight Study.

1. Introduction

Japanese Tea House is a traditional form of architecture that is designed to hold a tea ceremony ritual. As a highly spiritual culture ritual, one of the most essential parts in tea ceremony is the tranquil atmosphere created in the tea house and the light environment has undoubtedly played a significant role in creating the desired atmosphere. Those skillfully designed lighting strategies are considered the factors that enhance the experience of the tea ceremony. Tea culture has also undergone transitions in history which have also significantly influenced the lighting design strategy (Pitelka, 2003). For instance, as one of the most influential tea master, Sen no Rikyu had a profound influence on the ideology of the tea ceremony and tea house design. Sen no Rikyu introduced the idea of Wabi into the culture of tea. The idea of Wabi, as a representation of simplicity and imperfection, has a significant impact on how the visual environment is designed. This kind of influence has always been reflected in the lighting design of tea house and resulted in a variety of lighting designs. In order to deepen the understanding of the visual environment in tea house, this study aims to investigate the visual environment through the perspective of exploring the relationship with the tea ceremony ritual.

2. Background and Objective

One of the essential features in traditional Japanese architecture is to create a spiritual harmony response through the design of the light environment. The
balance maintained between light and dark is key to compose the atmosphere in Japanese architecture (Tanizaki, 1975). Especially in the tea house, as a room specifically designed for holding a spiritual ritual.

Ogiso and Sugimoto (1975) use a configuration factor method to calculate the light distribution in a tea house room and the light distribution diagrams are studied for discussion of tea house opening strategy. However, the calculation method used in these studies fell short in considering the property of material and change of daylight. Previous studies that use conventional methods failed to consider many factors that are essential in forming the visual environment of tea house such as window property and time shifting. In general, applying a simulation tool in the lighting environment study of tea house has not attracted many scholars. With the advantages of the daylight simulation tool, it is possible to study the lighting environment at a specific time of day or in a year and it improves the accuracy of the result by differentiating the properties of the architectural materials. The simulation output provides visual graphics data and quantity daylight data which allows a more in-depth and comprehensive discussion about the daylight condition.

This study aims to introduce a new way of incorporating CAD and simulation method to the light environment study in tea house. Through building the tea house in a 3-dimensional interface, the investigation offers a more comprehensive understanding of how different elements such as windows, orientation, and shades are manipulated to achieve the lighting effect. The digital approach allows the tea house to be studied more intuitively with a more accurate output. Furthermore, it is undeniable that the tea house designs are also heavily influenced by the design intention of tea masters and the culture of tea. This study also focuses on interpreting the simulation result through the understanding of tea ceremony.

3. Methodology

3.1. 3D DIGITAL MODELLING

Table 1. Tea houses analysed in this study. Note: Tea houses information in the table is collected from Kokuhō jūbun no chashitsu (Nakamura, 1997).

<table>
<thead>
<tr>
<th>Tea house</th>
<th>Tea house Designer</th>
<th>Built Year</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taian</td>
<td>Sen no Rikyū 千利休</td>
<td>1583</td>
<td>Earliest grass-mode tea house ( Influenced by Wabi Kusa)</td>
</tr>
<tr>
<td>Joan</td>
<td>Oda Yūraku 織田長益</td>
<td>1618</td>
<td>Unique style of window design</td>
</tr>
<tr>
<td>Shumono</td>
<td>Oda Yūraku 織田長益</td>
<td>Around the end 16th century to early 17th century</td>
<td>Known for its number of windows</td>
</tr>
<tr>
<td>Hassan</td>
<td>Kobori Enshū 小堀遠州</td>
<td>1624–44</td>
<td>Unique Long three mats layout</td>
</tr>
<tr>
<td>Hassoseki</td>
<td>?</td>
<td>1628</td>
<td>The main openings face north</td>
</tr>
<tr>
<td>Saan</td>
<td>Kounoike Ryosei 橋池了應</td>
<td>1603</td>
<td>Slender shape layout with main openings facing north</td>
</tr>
</tbody>
</table>
In order to investigate the architectural features of the traditional tea house, tea house models are firstly built in the 3D digital environment by using Rhinoceros 3D interface. The tea houses are modelled in detail including the structural elements that are exposed on the surface for the purpose of obtaining a more accurate simulation result. Six traditional tea houses which include Taian, Joan, Saan, Shunsoro, Hassoan and Hassoseki are modelled and studied in this research. In order to have a group of more diverse study targets, six tea houses vary in terms of the designer, the period being built and size et al. (see Table 1).

3.2. DAYLIGHT SIMULATION
The digital models are then used to carry out the daylight simulation with DIVA daylight and energy simulation plug-in in Rhinoceros3D. Diva combines a daylight coefficient approach with the Perez all weather sky model and the RADIANCE backward ray-tracer to carry out daylight and other weather simulation for studying the building performance (Hensen & Lambergts, 2011). In DIVA, predefined material options with different reflection rates are available to assign to the geometry. In this study, materials are selected based on their colours and reflective rates in the real-world situation. The sky condition for the simulation is set to be the CIE clear sky with a sun condition. The simulations are carried out for each tea house in three typical dates which are summer solstice date, winter solstice date, and one equinox date. As DIVA allows the region-specific weather file to be input for the simulation, the location setting is set up as the realistic location for each tea house.

3.3. TYPES OF SIMULATION RESULTS
There are two types of simulation result are obtained from simulation: daylight distribution diagram and 3D visualizing image. In the simulation of daylight distribution, the floor of each tea house is set to be the targeted analysis surface with a grid of sensor nodes assigned onto and the simulation is carried out at the defined sensor points. (Jakubiec & Reinhart, 2011). The daylight distribution diagrams are used to evaluate the amount of light and how the light is distributed on floor level in each tea house which would indicate the area that is illuminated or accentuated by daylight. Through a comparison of the patterns in targeted tea houses, the study aims to discuss the transition and difference of the lighting strategies of different tea masters. The 3D visualizing image visualizes the lighting scene in 3D environment which provides a more intuitive visual data that would be used for discussion of the interior atmosphere and the visual environment of tea house.

4. Findings and Discussion
The findings part is presented as three sections. In the first section, the results of the daylight simulation are presented and interpreted. It is followed by the discussion of windows which explain how the light environment is created by the design of windows. In the third section, the paper discusses how the ideology of tea master and tea ceremony influenced the lighting strategy in tea house.
4.1. DIVERSE PATTERNS OF DAYLIGHT DISTRIBUTION IN TEA HOUSES

4.1.1. Simulation result comparison in different tea houses

The results of daylight simulation have shown very diverse patterns in the daylight distribution diagrams when compared to the result from six tea houses that have been analysed (see Figure 1). The difference firstly appears to be the overall amount of illuminance value inside the tea house. The mean illuminance value shows significant differences depending on the orientations and the design of the window.

Although the design of the window is the main factor contributing to the difference in the light quantity, the orientation of the house certainly results in a more significant impact. As it can be seen in the case of Hassoseki, as one of the minorities in tea houses that the main openings face toward north has received much less intense light compared to the rest. Despite the large size of the openings and the number of windows, it also receives an extremely limited amount of light. In the cases of Shunsoro, Hassoan, Hassoseki, which have more windows compared to other tea houses, the results show more complexity in the light distribution responding to the shift of time. With the increasing number of the source of light, the interior became more complex and unpredictable.

To sum up, although there are some certain common design principles involved
in tea house design, the light environment tends to have very unique pattern in relation to the designer’s intention and the tea ceremony ideology at the time. There are is no singular pattern or rule that could be found in the tea house light environment.

4.1.2. Light environment pattern in one tea house

![Simulation result for Joan.](image)

When looking at the simulation result from one tea house. The daylight distribution diagrams indicate a very variable light distribution pattern on a different date and at a different time in a day (see Figure 2). Overall, it can be seen from all the tea house simulation results that have been conducted so far, the light is generally not uniformly distributed in tea house because of the way the windows are designed. It is also due to the south-facing orientation, which would result in more dynamic changes in daylight. The light tends to concentrate in a different location in the tea house responding to the movement of the sun.

The daylight distribution diagram provides plenty of information because the functions of the different area in a tea house plan are determined. For example, as the floor of the room basically consists of the Japanese mats (tatami), and the sitting position of tea host and guest are also determined. Temaeza as the host mat is the area where the tea master would sit and perform the tea ceremony ritual,
while the opposite side is where the guest would sit. Tokonoma is a specific space in a tea house for displaying an art object in the tea house. Therefore, the daylight distribution diagram could provide an insight into the designer’s intention about which part of the room the designer intends to illuminate.

4.2. DESIGN OF WINDOWS

4.2.1. Window Composition

One of the features that have been found in four of the tea houses is that the windows are dominantly located on the west side. In six tea houses that have been modelled and analysed so far, four of the tea houses have one large window that aligned to the edge on one side and the other window closely located almost at the same height on the other side which combined to form the largest opening in the tea house. This type of window composition would allow more daylight to be introduced while the sun is in the corresponding location. In the five cases that included so far, those opening corners mainly oriented toward the west which means the daylight would dominantly be brought into the room mainly during the early to late afternoon. The layout of the tea house would result in the sunlight to be concentrated in the location where the guests sit. This kind of opening strategy can be argued to be one of the tactics used to allow the tea house to be mostly brighter in the afternoon. And considering the location of the windows, they also avoid light to be concentrated on the tea host location.

4.2.2. Effect of Shoji

Figure 3. Simulation carried out in Joan with shoji attached to window (June 21st 14:00).

Figure 4. Simulation carried out in Joan without shoji attached to window (June 21st 14:00).
One of the other factors that have a great impact on the lighting in tea house is the use of Shoji. In traditional Japanese houses, windows usually consist of translucent paper that is being held by a lattice frame. The paper used here is called shoji and it could diffuse light which would create a different lighting effect in comparison with modern glass or other material. In this study, the daylight effect that resulted by passing through the shoji is compared with the situation without using shoji in the simulation (Figure 3&4). It can be seen from the simulation results that the shoji could result in a much more diffused daylight effect. It not only reduces the total amount of light due to the lower transmission but also makes light scatter as it passes through. The dim visual effect that resulted by Shoji creates a unique atmosphere by reducing the intensity of light.

4.3. RELATION WITH TEA CEREMONY RITUAL

As the Japanese tea house is a very small space that heavily relies on daylight for interior lighting, the shift of light condition during a day become even more notable in the room. The significant variation in light and variety of pattern of daylight distribution in the room indicate a very intricate light strategy. It is important to understand that the role of tea house is primarily a tool and space designed specifically for the purpose of holding a tea ceremony. The unique pattern of the light environment found in tea house should suggest a correlation to the tea ceremony itself.

4.3.1. The Contrast of daylight during a tea ceremony

One important pattern that has been found is that not only the daylight condition could have a significant change between morning time and afternoon, but also the light is usually intensively introduced to the room in the afternoon. As it is mentioned in section 4.2.1, as a result of the window location, the light would be dominantly introduced during the afternoon period. This indicates the designer’s intention on how they want to create a contrast between the first half and the second half in a tea ceremony. As tea ceremony ritual usually last four hours or more, the transition of the light condition in tea house is viewed as a distinctive part of the tea ceremony. This is one of the important tactics that used to create the contrast during different phrase in a tea ceremony gathering to allow the guest to experience a change in the atmosphere during the ceremony. Light is usually suppressed intentionally in the first half of the ceremony and it is considered ideal to have brighter lighting in the second half and latter phrase (Nakamura, 1997). This is intentionally designed to be the opposite of a normal daylight situation where it gets darker as time passes. By composing this kind of light scene, it aims to make people forget about the passing of time during the tea ceremony ritual.
4.3.2. Light environment and visibility during a tea ceremony

It has also been found that there are few cases that the area in front of tea master is intensively illuminated. This is the area where the tea master would perform the ritual of tea ceremony that involves making tea by using the utensils. The appreciation of the utensils used in a tea ceremony is considered to be one of the most central parts of the ritual. In addition, as tea ceremony practice is also considered as the art of a set of the body movement, observing and appreciating the performance of tea master is also an essential part of a tea ceremony. For example, even in a small procedure like “examining a tea whisk”, it involves a series of rules and etiquette. According to Chado (Sen, 1977), this procedure includes prescribed body movement of moving the utensil and certain hand gestures displayed while grasping the utensil. In order to have a better capture of the atmosphere, the situation of a tea master performing in tea ceremony ritual is simulated by putting the human figure inside the digital model. As it can be seen in figure 5&6, in a small space such as tea house the light and shadow are even more distinguishable, and the lighting condition can heavily affect the visibility of the guest. It further accentuates the area that is brighter. And from the visual image, it could be argued that bright or concentrated light may be rather detrimental than beneficial for the purpose of appreciating the movement of tea host. In the situation of Joan where the light directly pointed to the body of tea host and the utensil, it affects the colour and the visibility for guest (see Figure 5). The utensil may be viewed differently as a result of strong light and possible glare. The situation in Shunsoro where
the tea master performs under dim light environment make it more favourable for observing the tea master with less glare (see Figure 6).

Hence, it could be argued that the bright light is more detrimental for appreciating tea master’s performance. The simulation results also reflect the idea insisted by many tea masters that utensil should not be illuminated overwhelmingly as it can affect the way people appreciate the utensil (Nakamura, 1997). The simulation results prove that the lack of light is an intentionally designed effect by a tea master.

4.3.3. Transition of the ideology

Tea culture has undergone an extensive transition in history and those transitions also have significant influences on tea master’s perception toward designing the interior daylight (Pitelka, 2003). The design ideology regarding the light has been evolving and changing through times and different tea masters may hold various approaches on the way they use the light.

As can be seen from the simulation result, the tea ceremony is generally held in a very dark environment. Being affected by the opening strategies and shades, the rooms generally do not receive sufficient daylight by the common standard. The light is generally subdued by applying many manipulations including orientation, opening strategy, and material. This kind of light design strategy may be predominately influenced by Rikyu’s idea of Wabi.

The ideology of Wabi is a traditional Japanese aesthetics and one of its ideas that influenced light environment design in tea house is its representation of simplicity. Along with the appearance of the grass-hut mode of the tea house introduced by Rikyu, Rikyu believes that suppressing the light and making the tea room to be dark is one way to achieve the Wabi’s ideology of simplicity and imperfection. He believes that blocking part of the light and spill only a limited amount of dim light from the lattice window would create a desired atmosphere to appreciate the art of tea. In contrast to the lavish style of the tea culture prior to the Rikyu’s time, the darkroom environment is considered to be an adaption to the transition toward the Wabi style tea house (Pitelka, 2003). The result of simulation also demonstrates that this kind of tactic could have an effect of accentuating the illuminated area in a general dim environment which could allow tea master to emphasise the part of tea house by manipulating the light. The design of the opening is only one aspect of influence Rikyu brought to the lighting in tea house. Before the era of Rikyu, the side of the tea house with the largest area of the opening would normally face north. And it is a tactic that tea masters before Rikyu used to avoid the fickle sunlight from the south direction. It is a very effective way as the simulation result shown in the Hassoseki, which is a tea house that faces north. It shows that there are fewer changes are introduced in the lighting environment. It was Rikyu who started to orient the tea house toward the south to allow the tea house to have a more intricate interior light environment as a result of south side daylight (Nakamura, 1997).

On the other hand, after the Rikyu period, the culture of tea become even more prosperous and the tea house design also became more diverse (Nakamura, 1997).
As it can be seen in the tea house such as Hassoan and Shunsoro, the setting of windows becomes less restricted and more and more tea masters tend to design a more complex light scene by integrating more windows into the room (see figure 6).

5. Conclusion

This research aims to develop a deeper understanding of the relationship between the daylight environment and the tea ceremony ritual. The study investigated the light environment in six traditional tea houses and compared light environments between them by using daylight simulation method. The result shows unexpected variations in the pattern of the interior light environment for each tea house. When looking at one particular tea house, the simulation result suggests a very intricate and unique light environment in the interior as it could shift rapidly in a day and introduce a diverse distribution pattern. Considering tea ceremony usually last around four hours from the morning or noon to afternoon, the participants would experience an interesting transition during the ceremony. By incorporating CAD and simulation method in the study, the data obtained from the daylight simulation tool clarifies some of the design intentions claimed by tea masters. The result also proves that some of the tactics used in daylight designs comply with the principle and ideology of tea ceremony. On the other hand, the variation shown in different tea houses indicates different lighting design strategies are used by tea masters. Some of the results strongly show the distinctive design intention of the tea master and the ideology of tea at the time. Through adopting a digital approach in this study, the study aims to provide a new perspective in the tea house lighting study by incorporating digital CAD method and simulation tool. In terms of the future study, the research aims to evaluate more tea houses and take a deeper look at human behaviour and the possible influence light environment has on humans in the tea ceremony.

References