Lighting Features in Japanese Traditional Architecture

Cabeza-Lainez J. M, [1]Saiki T. [2], Almodovar-Melendo J. M. [1], Jiménez-Verdejo J.R.[2]

[1] Research Group KARMA, University of Seville, Spain
[2] Theory of Design Division, University of Kobe, Japan

ABSTRACT: Japanese Architecture has always shown an intimate connection with nature. Most materials are as natural as possible, like *kaya* vegetal roofing, wooden trusses and rice-straw mats (tatami). Disposition around the place, follows a clever strategy of natural balance often related to geomancy like Feng-Shui and to the observance of deeply rooted environmental rules. In this paper we would like to outline all of the former, but also stressing the role of day-lighting in architecture. Unlike Spain, day-lighting is a scarce good in Japan as the weather is often stormy and cloudy. Maximum benefit has to be taken of the periods in which the climate is pleasant, and a variety of approaches has been developed to deal with such conditions; latticed paper-windows (*shôji*), overhangs (*noki*) and verandas oriented to the South (*engawa*), are some of the main features that we have modelled with the aid of our computer program. The results have been validated by virtue of on site measurements.
The cultural aspect of this paper lies not only in what it represents for the evolution of Japanese and Oriental Architecture but also in the profound impression that those particular lighting systems had for distinguished modern architects like Bruno Taut, Antonin Raymond or Walther Gropius and the contemporary artist Isamu Noguchi, a kind of fascination that we may say is lingering today.

Keywords: Japanese Architecture, lighting design and simulation

1. INTRODUCTION

It has often been said that Japan is a land of contrasts. This is clearly seen when we consider the extreme variety of its climates. Tall mountains perpetually powdered with snow (see Figure 1) are compatible with a scorching summer's heat and the surprising dryness of the winter is followed by an extreme degree of humidity in monsoon-marked weather.

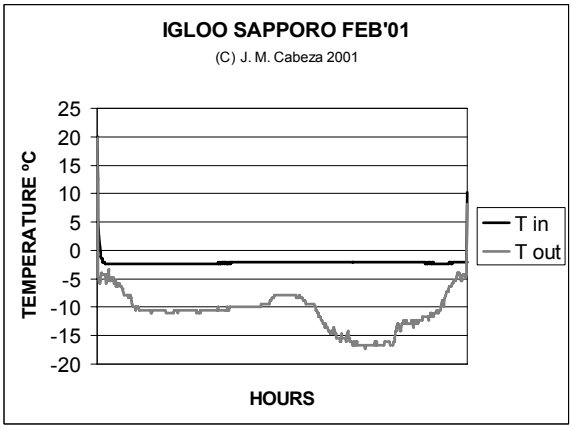

Figure 1: Temperatures inside an igloo constructed by the author in Northern Japan. Outside temperature reaches -17ºC.

As in many other regions of the world, Japanese architecture has evolved through the years in accordance with the climatic facts described above.

However, we have to make an important distinction with other countries: in Japan reverence for the environment is the main feature of Sacred Architecture and thus it is found here more steadily than in civil or even vernacular buildings.

Figure 2: A watch-tower said to have marked the sun's position, reconstructed from the Jômon Era (Some 3.000 years ago). The posts of chestnut wood are 15 metres high. Location: Sannai Maruyama (Aomori).

There is a general belief supported by Shintô Religion that the land belongs to natural spirits (the *kami*) and permission to dwell in a place should be obtained by the builders.

The way to receive this boon is to follow the architectural traditions and to observe ceremonies like the *tatemae* (literally: before construction).

An example that witnesses the importance of sunlight for the Japanese is a report from old age chronicles, mentioning that Amaterasu the Sun-goddess, during a period of seclusion from worldly affairs, deprived the land of Light. Upon Her return, She bestowed on Her sibling, the first emperor Ninigi, a Holy Mirror, spelling the words: "Thou shalt worship this Mirror as if it wert Myself"[1]. The mirror is treasured today at Ise Shrine as pledge of the alliance between Humans and Heaven.

2. VERNACULAR EXAMPLES

In accordance with the former, traditional architecture, whether sacred or popular, has always devised smart features to treat the light and the sun (Figure 2).

One of these features is the Shôji, a tiny wooden lattice, covered with panes of oiled paper, relatively impervious and resistant to the wind that works as a kind of sliding door and window. (Figure 3)

The shôji is not transparent, and also we have measured that its transmittance ranges from 0.5 to 0.6 depending on time and weather condition.

Therefore, it helps to avoid unwanted glances but when the sun impinges on such a wall, light intensities on its vertical plane are greatly reinforced. As it is not glazed, the greenhouse effect associated with solar radiation is kept low.

Figure 3: View of a typical shôji

On the other hand, when the sky is cloudy the shôji produces pleasant though gloomy interiors.

These interiors seem to be appreciated by the Japanese people and they are the subject of a celebrated essay named "In Praise of Shadows" by the novelist Junichiro Tanizaki [2].

We have prepared a simulation of a typical house in Kôbe, assuming that the main walls are made of shôji and we take into account the influence of the eaves (noki) by suppressing or adding them in the calculations.

This procedure is based on radiative transfer of flux and details of it can be found in reference [3].

The simulation has been conducted at 12 hours solar time (noon) both under overcast sky and clear sky with sun. The dates chosen haven been June and December around the solstice. (Figures. 4 and 5)

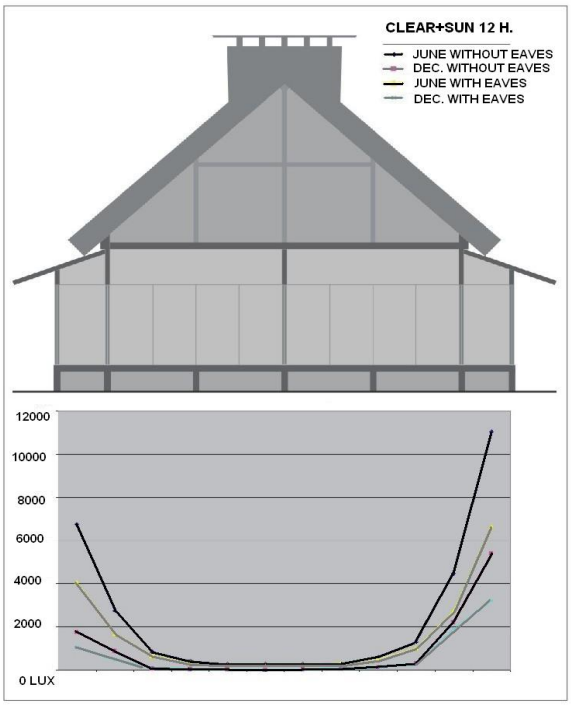

Figure 4: Simulation model of a popular house called Minka. Dimensions of a module: 3.60 X 7.20 m. Lighting levels may reach 4.000 lux near the shôji with eaves, but in the core of the room the intensities are almost negligible.

At certain times of the day, if the room becomes too dark the only solution is to slide the shôji and leave the wall open in order to increase light, however, in this process some inconveniences like insects or wind may appear.

The soft oiled rice-paper is not only employed in the shôji, artificial lighting fixtures like *andon* (lamp), lanterns or even streetlights also used this material.

In contemporary architecture several attempts have been made to include paper walls in the design while avoiding the problems of fire-proofing and excessive need for repairs.

Some of them consist of inserting a layer of translucent paper between two sheets of glazing. Another way is to keep the shôji as a kind of curtain inside a typical glazed wall with metal frame. By doing this the owner can benefit from the shôji in good weather and be protected from the cold and the fires by a solid transparent wall.

However, no modern system is capable of replacing completely the properties of the original and some say that this is due to the special characteristics of the Japanese mind trained in an elliptical culture where fuzzy vision is often preferable to sharp contrast [4]. This is also the argument of the aforementioned writing by Tanizaki.

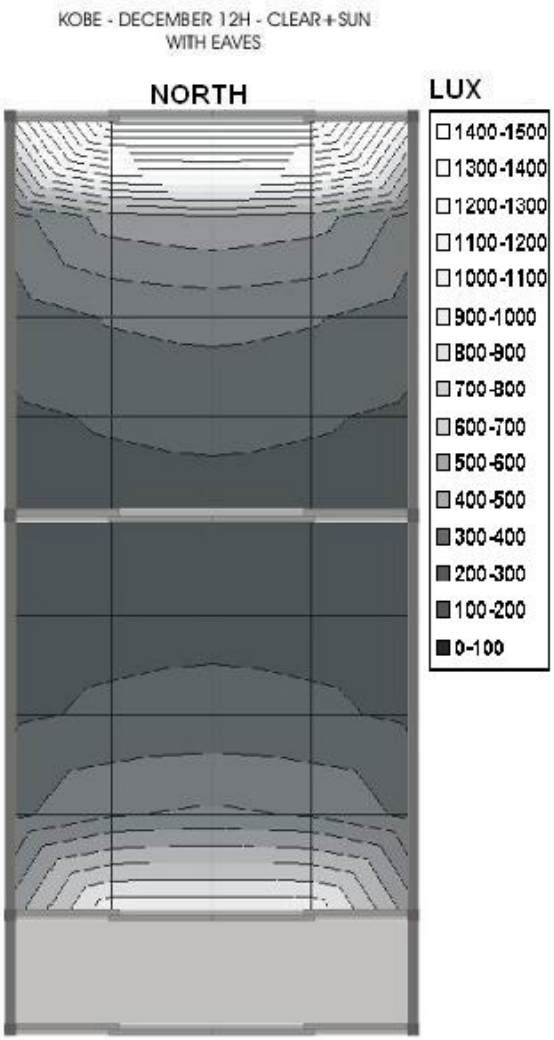

Figure 5: Lighting distribution in plan with eaves (December 12h.). The engawa and noki are very effective in controlling the solar radiation as both facades (North and South) present similar levels around 1400 lux. The soft nature of the oiled paper also helps to reduce glare.

3. TEMPLES

In many sacred buildings the devices used to treat radiation are even more carefully planned and designed than in dwellings. A well-known case is that of the Karesansui or "Dry Gardens". The Karesansui are void spaces treated like a shallow pond filled with rocks and gravel that are set in front of the main Hall of a temple. Their principle aim is to help in Zen meditation by offering concentration to the mind. We will not discuss here their many aesthetic or spiritual properties but we have observed that this type of garden is invariably oriented to the South and the colour of the sand employed to decorate it is always white or clear.

We decided to apply our simulation method to this special compound of reflective surfaces and chose the famous precinct of Ryoanji in Kyôto, made of raked sand with a disposition of 15 rocks. (Figure 6)

Figure 6: View to the South of the Garden of Ryôanji in Kyôto. Notice the rocks apparently immersed in white gravel and the surrounding walls and trees.

At the temple, the enclosing southern eaves get reflected radiation from white quartz sand. That material is very porous and, consequently, it will not heat up as much as other materials. In summer values of around 8000 lux have been measured on the underside of the wooden roof. (Figure 7)

Figure 7: The Southern eaves of the temple at Ryôanji with light-coloured wooden rafters.

We have conducted our simulation for a typical summer day considering intensities of up to 100000 lux on the horizontal plane [5]. The results (See Figure 8) closely agree with the measurements taken on the site.

This simulation proves that the design of the Karesansui greatly improves day-lighting inside the temple; the colour and orientation of the surface are not casual as the gardens in all other orientations are covered with moss of low albedo. On the other hand, inclination of the roof reinforces the effect of conveying light to the main altar which is also composed of reflective materials like mirrors and gold leaf.

The gardens of this type may constitute the first light-shelves in History, they come out of a spiritual need for "enlightenment" (satori) but they also enhance physical illumination and they may be the only resort in a near-tropical climate where another kind of disposition to reinforce light such as a skylight

would be impractical because of heavy rain and high solar altitudes. On the other hand, this reflection system helps to reduce the limitations of the shôji previously described.

The Karesansui works equally well in summer and in winter and it is indeed a “sacred place” because maintenance is difficult and expensive in the middle of the luxuriant vegetation of Japanese woodland.

Another name for Karesansui is Saniwa (sand garden) an old denomination of fortune-tellers in the Heian Era. Thus, the name suggests that important private ceremonies could have been celebrated there in older times.

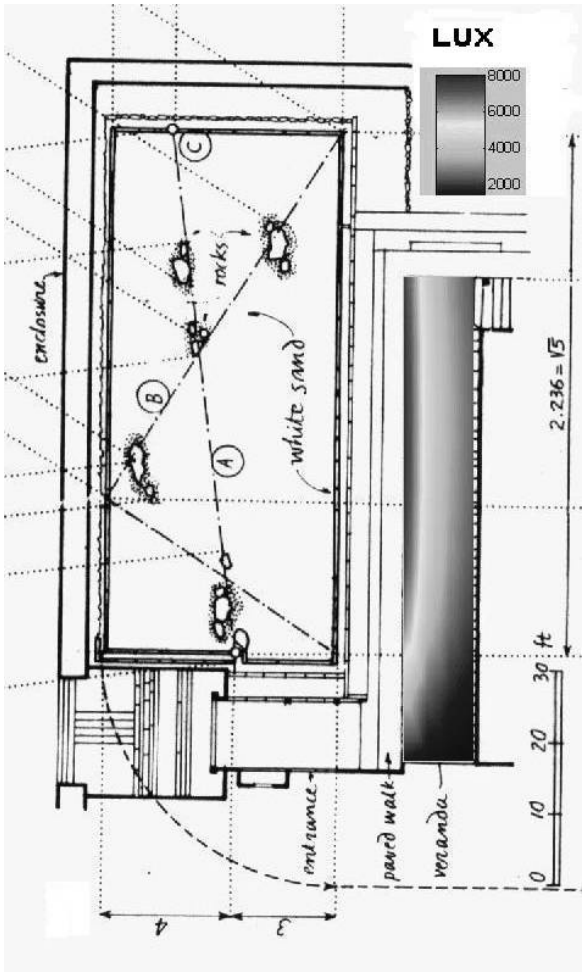

Figure 8: Radiation field under the roof of the temple of Ryôanj showing an average value of 5000 lux.

4. MODERN EVOLUTION

As it could be expected, by the end of the 19th Century Japan opened itself again to the world; many of the outstanding environmental features of its buildings were prone to change.

Nevertheless, modern architects realized the potential that traditional design solutions had in the contemporary scene. A dramatic effort was made to revitalize elements like the ones that we have studied in the first pages.

One such effort was undertaken by Bruno Taut, a political refugee in Japan from 1933 to 1936, who immediately admitted that “the modern Japanese have in their houses a quite right point; the traditional Japanese house can no longer be inhabited by the current people of Japan…people who sit in chairs and tables will no more stay crouched under the *kotatsu* wearing several layers of kimonos or remain trembling in the house while the cold winter winds whistle through the rattling *shôji*.” [6]

Figure 9: Window conceived as a folding screen designed by Bruno Taut at Hyuga House. Atami.

Taut devoted himself to the task of finding a modern idiom for the climatic elements of the Japanese house, especially in the aspects of sun and light control or ventilation (Figure 9). The highpoint of this process was his protracted sketch for the facades of the Okura Villa in Tokyo where he incorporated noki and engawa with a kind of light-shelf intended to ensure ventilation in the rainy periods. (Figure 10)

He had started as an industrial design teacher in Japan and his models of lamps and furniture were sold at the Miratiss shop in Tokyo. He was convinced that lighting on the table plane at a Japanese traditional house was inadequate, and his section with increased height and clerestories would contribute to remedy this major drawback boosting the production or European-style chairs and tables, a curiosity at the time in Japan.

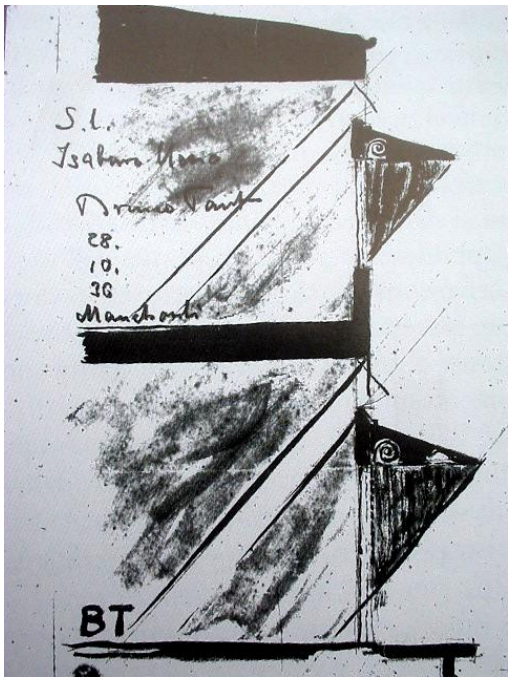

Figure 10: Sketch for a section of the Okura Villa in Tokyo. Notice the patterns of sun-rays and shadow drawn by Bruno Taut and the case for venetian blinds.

We have simulated this section in winter and in summer to assess its performance (Figure 11) and we have found likely that the levels of illuminance would be augmented as compared with the traditional facade when the sun is present. However, under cloudy sky the level of light is very low and the effect sought by Taut may not have been realized. Even so, he maintained this section in his posthumous projects of 1938 for school buildings in Turkey (Ankara, Trebzon and Izmir)

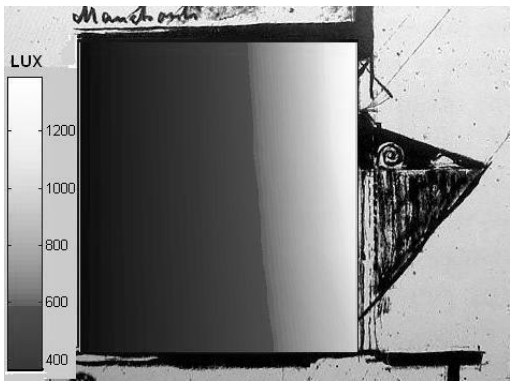

Figure 11: Summer sectional distribution of daylight at the Okura Villa.

Another important architect who took great pains to preserve a Japanese light in his projects was the Czech-American Antonin Raymond. Together with his wife, the artist Noemi Pernessin, they established a practice in Japan in 1920 that lasted until 1970.

Figure 12: The Raymonds at their house and studio at Azabu (Tokyo). Notice the wooden columns and the shôji window.

As in the case of Bruno Taut, the Raymonds were always concerned with the use of natural materials adapted to the Japanese climate. In fact, this was the main source of problems in their association with Frank Lloyd Wright for the Imperial Hotel at Tokyo [7]. Antonin Raymond extracted many lessons for his projects from the traditional solutions that he knew so well as a result of his frequent trips and explorations in the country before the Pacific War.

Figure 13: A representative work by Raymond, the house for F. Inoue at Takasaki with shôji, andon lantern and a Japanese garden to the South.

But his genius was not restricted to Japan. In 1937, forced by the rise of militarism, he left Japan temporarily but he managed to build an extraordinary compound in Pondicherry (India), the Ashram for the guru Sri Aurobindo. Here in two tall blocks of dormitories for the disciples, the first modern brise-soleil appears in all its magnitude. The drawing of Raymond's explains succinctly that this is a façade intended for buildings in tropical climates.

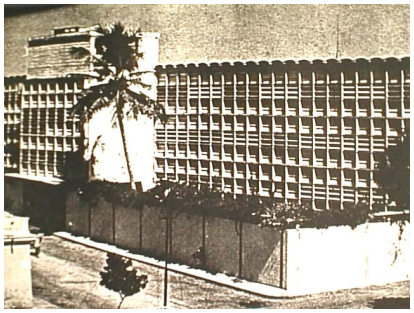

Figure 14: View from the South of the Dormitories in the Ashram of Sri Aurobindo. Pondicherry. India. Notice the façade covered with blinds made of mineral fibre.

Figure 15: The brise soleil from the inside of the rooms.

Influenced by his intense experiences in Japan and later at Angkor Wat, [7] Raymond became aware of the importance of shadow and reflected light in Asia and thus he adapted the properties of horizontal "mirrors" to buildings several storeys high. The performance of such a system was rather adequate compared with a conventional window (See Figure 16)

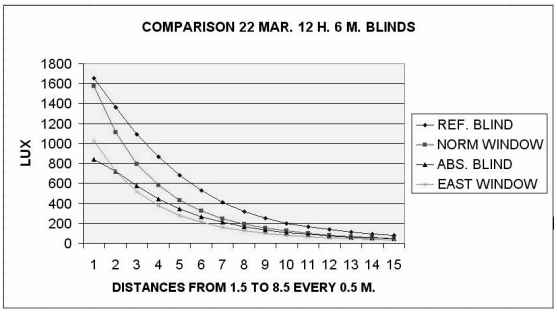

Figure 16: Simulation of the effect of blinds of different colours in Raymond's project, compared with a room without blinds oriented to the South and to the East.

5. CONCLUSION

Japanese traditional architecture is unique and truly environmental and thus Japanese people and their architects have developed a natural sensibility towards lighting features and strategies.

This inclination manifests itself in the works of recent artists and creators but also in forgotten scientist like Jiro Yamauchi who in 1932 defined for the first time the concept of Photic Field [8] which was to be the basis for later works of Higbie, Moon and Spencer among other pioneers of lighting science.

Following his theories and example we have striven to demonstrate with the help of contemporary simulation tools the efficacy of the solutions that were so inspirational in his work and that still continue to exert their influence on designers from all countries who approach the question of sunlight with naïve and contemplative eyes.

To show the importance of light as a timeless way of expression in the Oriental mind we would finally like to draw the example of a rare Chinese-Japanese character which depicts the Sun, the Moon and a Mirror-like object; generally translated as "Alliance" (ch. *Meng* jp. *Mei*), it suggests a lasting truce with Nature.

Figure 17: Tadao Ando. Church in the Water. Tomamu. Hokkaido. A reflective pond is used as main element of the space.

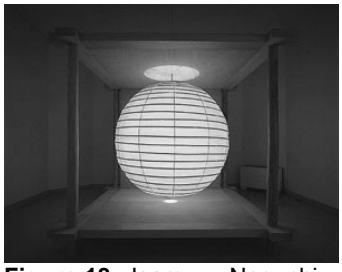

Figure 18: Isamu Noguchi. Two-metres Akari. Museum of Contemporary Art. Sapporo. Fascinated by Japanese light, the artist devoted himself to the creation of paper lanterns.

ACKNOWLEDGEMENTS

In this research of 15 years we would like to show appreciation for our Masters, Kenichi Kimura at Waseda and Yuichiro Kodama at Kobe.

The Odajima family has always being supportive regardless of how extravagant my research interest may have been. Let peace reign among them.

We would like also to thank the librarians at Kobe Design University for their tenacity in helping us to find the long-forgotten Yamauchi papers.

Juan F. Ojeda from the University of Seville was instrumental in the preparation of graphs for Bruno Taut's section.

REFERENCES

[1] *The Kojiki* (Old Chronicles of Japan). Tuttle Books. Tokyo. 1992.
[2] Tanizaki, J. *In Praise of Shadows.* Leete's Island Books. Stony Creek. 1977.
[3] Cabeza-Lainez, J. M. *Fundamentals of Luminous Radiative Transfer*. Crowley Editions. Seville. 2006.
[4] Plummer, H. *Light in Japanese Architecture*. A+U. Tokyo. 1995
[5] Shukuya, M. (1993) *Hikari to Netsu no Kenchiku Kankyogaku* –The environmentally conscious architecture of light and heat- (In Japanese). Maruzen. Tokyo.
[6] Taut, B. *Ich Liebe die Japanische Kultur*. Gebr. Mann Verlag. Berlin.2003
[7] Raymond, A. *An Autobiography*. Tuttle Books. Tokio. 1973.
[8] Yamauchi, J. *Theory of Field of Illumination*. Researches of the Electro-technical Laboratory. 1932. Tokyo. No. 339.