대한건축학회 창립80주년기념대회 및 추계학술발표대회논문집
제45권 제2호(통권 제84집) 2025년 10월 29일 ~ 10월 31일

2025년 추계학술발표대회 : 일반부문

롱샹성당에서 자연광의 디지털 재현

A Digital Recreation of Daylight in Ronchamp Chapel

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Abstract

This study is initiated with the following question: "Is it possible to recreate the idea of daylight in architecture suggested by the architect using the digital tool?" We presume it is possible to recreate daylight in architecture digitally. To prove the presumption, a church building is selected for this study: Ronchamp Chapel, designed by Le Corbusier. Specifically, this study digitally recreates the scenes of daylighting in the Ronchamp Chapel, featuring two perspectives: one from the North Tower and the other from an open space near the South Wall. The digital recreation of daylight in Ronchamp Chapel demonstrates its profound impact on architectural design, showing how effectively this digital technology can enhance our understanding of the role of daylight in architectural design.

키워드 : 자연광, 건축설계, 롱샹성당, 디지털 재현
Keywords : Daylight, Architectural design, Ronchamp chapel, Digital recreation

1. INTRODUCTION

Many architects regard daylight as an essential element in architectural design. Therefore, they try to make the natural sunlight flow into the building space through the openings with the proper direction, brightness, and colour.

Steven Holl once said, "Even inside a building, you need to be able to feel the passing of the day and see the sun setting." Holl always considered the daylight as the element which makes the building space as the one stabilises the residents emotionally with the flow of the sun. Similarly, Louis Kahn also considered the daylight as the essential element in his design (Buttiker, 1994). Kahn believed that the indoor space of a building should be capable of transmitting the daylight. The daylight should give the residents a feeling of the cycle of the day to grant them a comfortable life. While Le Corbusier focuses solely on making a space that allows much daylight for residence. It makes the residents feel pleasant and safe inside the building, with its intensity, the change of its angle and diffusion. He said, "I use light abundantly, as you may have suspected. Light for me is the fundamental basis of architecture. I compose with light (Le Corbusier, 1991)." Meanwhile, Tadao Ando sought a balance between daylight and shadow. Ando remarked, "As we grow less aware of the darkness, we forget spatial reverberations and the subtle patterns created by light and shade. When this happens, everything is uniformly illuminated, and object and form are limited to simple relations. The remedy to this situation is a restoration of richness to space (Ando, 1995)."

Similar to any other type of architecture, daylight plays an important role in church buildings. However, understanding the church can enhance the use of daylight in architectural design. Generally, churches have an atmosphere that is quiet, calm, and symbolic of faith. Visitors often feel the presence of God within the church, especially as daylight fills the space. In many religious traditions, daylight is considered a symbol of God, and the "spiritual phenomenon" that are separated from the sun.

In the 20th century, some architects sought to emphasize the importance of daylight, symbolizing it as a representation of faith in God. Le Corbusier designed the Ronchamp Chapel (Stoller, 1999; Gill, 2006) with openings of various sizes and shapes, incorporating colored glass to create a unique play of light. After the completion of chapel, Le Corbusier expressed to his client his interest in "the effect of architectural forms and the spirit of architecture in the construction of a vessel for intense concentration and meditation" (Le Corbusier, 1953). Tadao Ando designed the

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Church of Light by incorporating a wall with an opening shaped like a cross, which diffuses and transforms light into a symbol of faith. Similarly, Louis Kahn included two large openings in the roof of the first Unitarian Church of Rochester, enhancing the environment and encouraging students in the classroom to engage with their faith.

In this context, a question (Lee, 2020) arises: "Is it possible to recreate the concept of daylight in architecture using digital tools?" Therefore, this study investigates specifically the feasibility of reproducing the atmosphere of a church building with natural light. The processes involved and the results of this digital recreation are presented and discussed. In particular, this study focuses on digitally recreating the scenes of daylight in the Ronchamp Chapel.

2. RONCHAMP CHAPEL

Notre Dame Du Haut, which translates as 'chapel of our lady of the height', is located in Ronchamp, France. It consists of four primary parts of building: large central nave with the roof which looks like an empty crab shell, the main chapel, and two smaller side chapels which are known as morning chapel, and evening chapel. (see Figure 1)

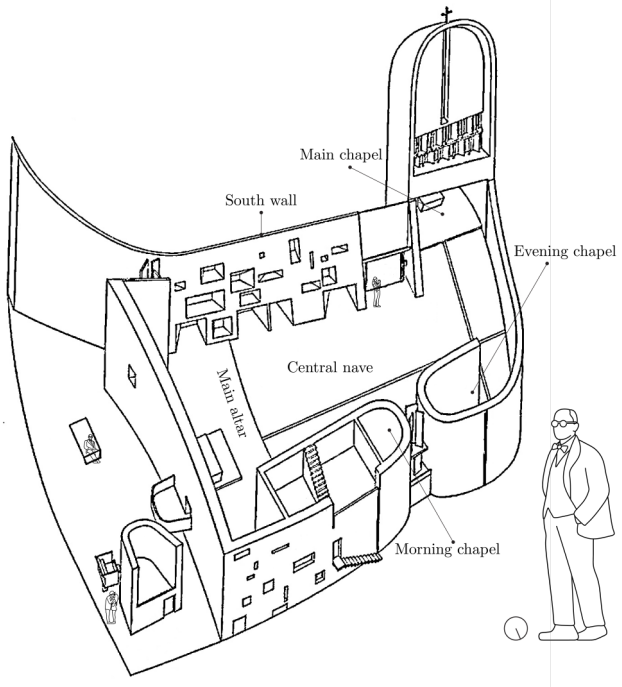

Figure 1. Axonometric of Ronchamp Chapel

Ronchamp Chapel shows Le Corbusier's philosophy about the daylight as surrounding nature. The existence of morning chapel and evening chapel seems to follow the sun's movement. He successfully made a change on both the regular designing method of churches and his usual method of designing the buildings with a wide window containing the facades inside. He was dedicated 'to create a place of silence, prayer, peace, and inner joy' for a new chapel in his way.

The daylighting in Ronchamp is divided into two types: one is collective light, and the other is individual light. In the case of an collective light, the daylight passes through the south wall with the various sizes of square openings, and this passing diffuses and colours the daylight into the space. It provides a calm and religious atmosphere to the visitors. The individual light appears at three towers. The light illuminates through the opening of the tower located at the southwest corner and the north wall. The towers that frame the entrance for visitors are designed with the brise-lumière, meaning "Broken Light." This design not only enhances the aesthetic appeal but also plays a crucial role in regulating the space.

3. DIGITAL RECREATION PROCESS

As described earlier, two spaces had been digitally recreated. The space near to the south wall is to demonstrate an collective light, and the illumination of the north tower is for individual light.

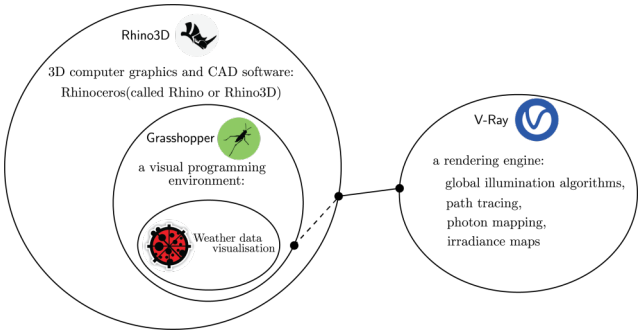

Figure 2. Tools and plug-in for digital recreation

Tools and plug-in (See Figure 2) such as Rhino, Grasshopper (GH), and V-Ray (VR) are introduced to preceed the digital recreation of individual and collective lights. Rhino is the CAD (Computer-aided Design) tool which mainly can create the geometry of building (architectural model) in the digital environment. The GH, a default plugin for Rhino, provides a visual programming environment. It can visually use most Rhino functions, so it is convenient to test the daylighting in the architecture by using GH component. In addition, the plugin VR provides sophisticated rendering capability on the top of the Rhino with plug-in GH. It applies the type of material, camera, and sunlight to the architectural design and creates real-time scenery.

In a visual programming environment, daylight testing in

the church space and recreating the lighting scene will be done systematically. The core process is illustrated in Figure 3. The first process is ❶ preparing the geometry of Ronchamp Chapel. We are importing the existing STL file and transform it into the VR geometry in the GH environment. ❷ After completing the geometry, the location of sun is created by using the LB component. ❸ Then, the camera route, which acts as human sight, is set by inputting specific numeral value into VR Camera components. ❹ Then, the coloured glasses inside the opening on the south wall of Ronchamp Chapel is created by using VR geometry components. After all these processes are finished, it is now ready to render the scene with VR.

4. RECREATION RESULT AND DISCUSSION

The recreated spaces show effects of colored daylight similar to the originals, although there are some differences (see Table 1). For individual light, as for the scene of the north tower, its lighting flows into the interior space through the small-sized opening, often emitting the red coloured light in the evening. In recreating collective light, we particularly explore the impact of light and shadow on the atmosphere in the nave, particularly focusing on the position of the sun. During the winter solstice, the amount of shadow significantly increases because the sun is positioned at a lower angle. This results in less sunlight entering the chapel due to earlier sunset times, making the interior space appear darker than usual. Conversely, during the summer solstice, the interior is much brighter than expected since the sun is at a higher angle, and the days are longer with later sunset times. It is important to note that the digitally recreated daylight scenes for both the winter and summer solstices do not include colored glass (see Table 2).

5. CONCLUSION

The ideas of daylight in Ronchamp Chapel suggested by Le Corbusier is sucessfully recreated in digital environment, while some elements are omitted due to the simplification of the digital model. The present recreation of daylight in Ronchamp Chapel demonstrates its crucial role in architectural design, showing how effectively this digital technology can improve our understanding of how daylight influences architectural design. By incorporating a real material model into the proposed digital recreation process, we can generate essential scientific data that will enhance our understanding of daylight in the Ronchamp Chapel and

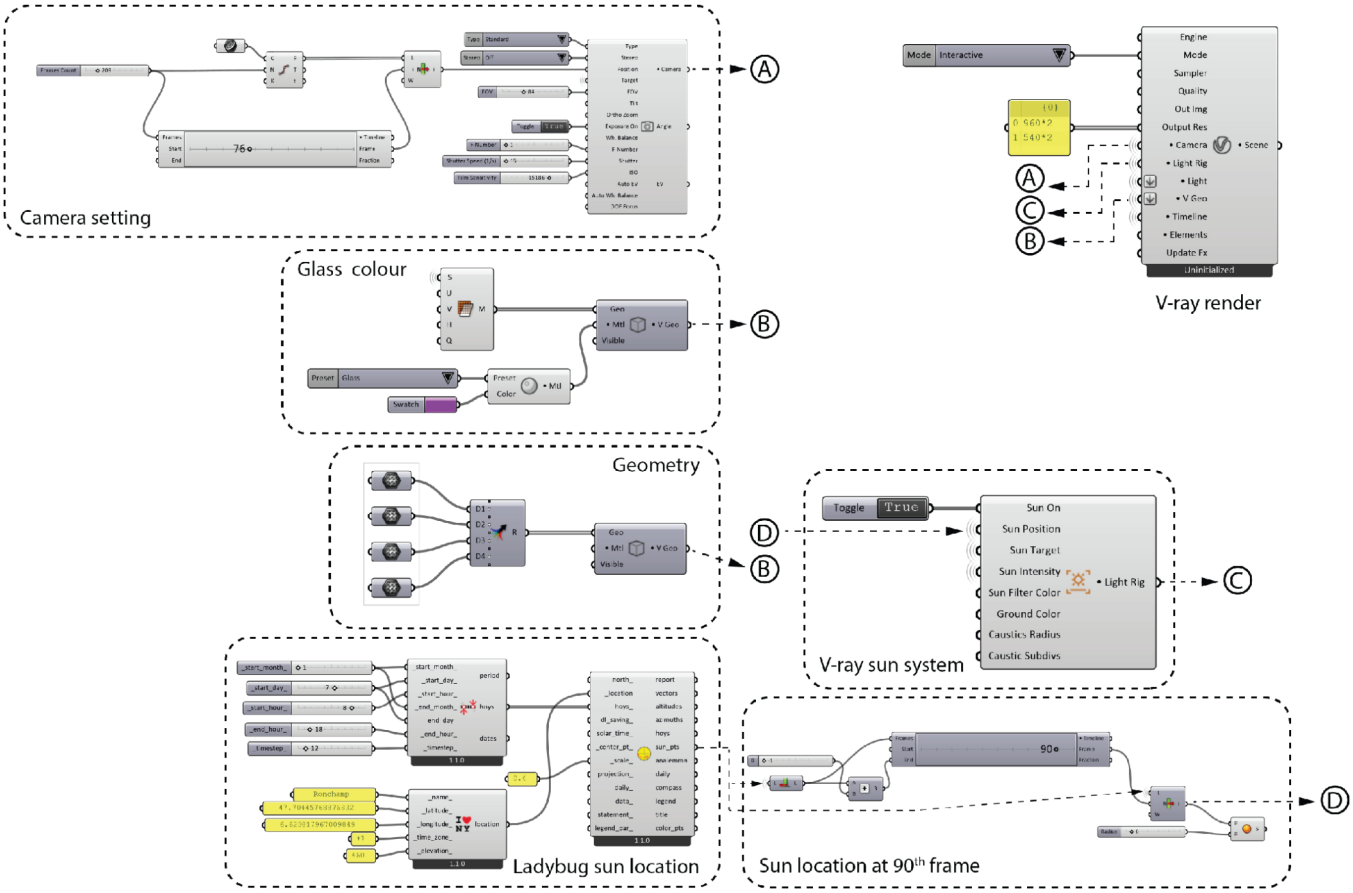

Figure 3. Core process for daylight recreation

its similar applications in the field.

ACKNOWLEDGEMENT

I am grateful to Prof. S.J. LEE for his support, and recent guidance in completing this paper.

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Table 1. Comparison between the results of digitral recreation and photographs

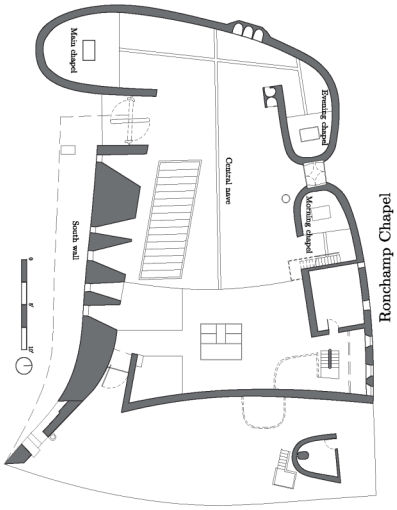
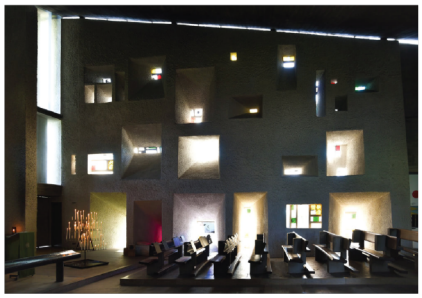
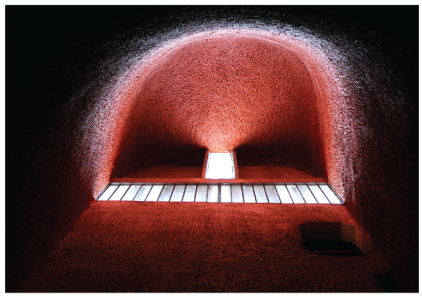
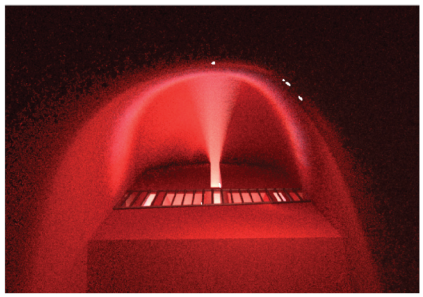
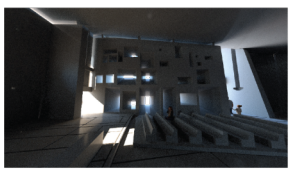
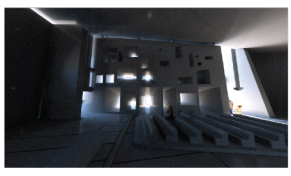
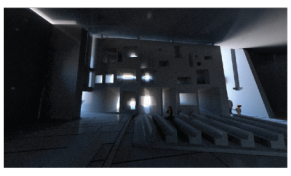
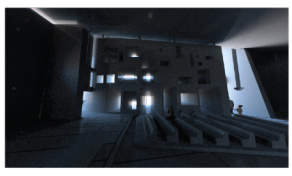
Plan		Photograph	Digital recreation (present)
	Collective light (south wall)		
	Individual light (north tower)		

Table 2. Digitally recreated scenes of the nave of Ronchampthe with positions of the sun

Time / Solstice	9:00	12:00	15:00	18:00
Summer solstice				
Winter solstice