The luminous environment at Ronchamp

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Word count (3977)
1. Introduction

One of the most influential buildings of modern architecture, Ronchamp is Le Corbusiers autobiography. It is the confession of his true nature as an artist, although being an architect Le Corbusier was also a prolific painter, a poet and a sculptor. A combination of all these remarkable skills composed together to produce a chapel at the top of the of the Notre-Dame-du-Haut hill in France near Ronchamp village, a worldwide masterpiece which has been a pilgrimage site for architects students and tourists since it was first opened to the public in 1954.

A fascinating chapel that sits on top of the hill, capturing light from all the horizons , but filtering it to create a remarkable experience from inside. It’s this experience that we will try to investigate but also understand the techniques behind it. The aim of this report is to investigate the luminance environment of light at Ronchamp. I am going to study thorough the transition of light inside and outside the chapel from sunset to sunrise. This will be done based on quantitative and qualitative analysis, physical model testing, ecotect, heliodon and finally artificial sky. It should be clear that this report does not intend to criticise or find faults but on the contrary, it is an appreciation of natural light inside a sacred space.
Le Corbusier called this poem "The Key". It is this poem that inspired me to study his work and more importantly light conditions at Ronchamp.

"The key is light
And light illuminates shapes
And shapes have an emotional power

By the play of proportions
By the play of relationships
Unexpected, amazing.

But also by the intellectual play of purpose:
Their authentic origin,
Their capacity to endure,
structure,
astuteness, boldness, even temerity, the play
of those vital abstractions which are the essential qualities
the components of architecture."
2. The creation of Ronchamp

- History

The hilltop was always being used for a site of holy significance. Le Corbusier’s Notre-daume-du haut is the most recent chapel to stand on site. Two more existed; the first one was a medieval church in the 19th century which was destroyed by a fire in 1913. A second chapel was immediately build in the 1920s but unfortunately was destroyed in a battle between the French resistance and German troops in 1944.

Up to 1913

1920-1944
- **Design Brief** “Corbu, help them”

In 1950 the manager of the photographic archives of France, the director of the museum of decorative arts in Paris and Canon Lucien Ledeur from the seminary of Besancon on the recommendation of Father Alain Couturier of Lyons approached Le Corbusier and asked for his help.

“... destroyed by lightning and wars... the latter time and time again, during the liberation it was destroyed by artillery. For five years over ambitious schemes have held up a solution. Corbu go there and do a good job.”

- **Concept**

Le Corbusier’s first design ideas behind Ronchamp were mostly inspired by his very first idea, “on the hill I had meticulously drawn the four horizons.” He was driven by the response to the site. “One begins with the acoustic of the landscape”. The roof was mainly inspired by the shell of a crab picked up on long island, New York in 1946. Le Corbusier’s patron for the building, Father Courturier, believed that an architect could best design an effective expression of spiritual consciousness if given the utmost in creative freedom. Le Corbusier’s unique creation at Ronchamp reflects Courturier’s artistic latitude, exhibiting an unconventional synthesis of iconography, architecture, and sculpture.

![Sketch showing his initial concept](image1)

![the shell of a crab](image2)
- **The Site, context and surroundings**

The chapel of Ronchamp is placed on a hill a few miles from the Swiss border in the Haute Saone region of Eastern France. Ronchamp is about 20km from Belford on the way to Vesoul.

1. Chapel
2. Outdoor chapel
3. Memorial pyramid
4. Pilgrims housing
5. Caretaker’s house
6. Path to summit
Site Strategy - The “Promenade Architectural”

Proposed by le Corbusier during the Twenties and very simply here the architect explains how important is for someone to understand the architecture of the building; he must also be linked to this notion of procession. How you approach, enter or exit all are very important. The architect attached great importance to the visitor’s route through the construction and direct perception to the building.

From the road linking Belfort with Vesoul the white outline of the chapel starts to appear as you go up the hill. Its abstract organic shape can be seen from miles. The adventure starts from the village of Ronchamp when the visitor takes a steep path and after arriving at the summit of path the visitor’s vision becomes shallower by the trees and bushes and then suddenly the whole building appears at front. On the other side of this path there are two more buildings which differ completely from the organic form of the chapel.
Orientation
The chapel’s two main facades are oriented towards the south and east, separated by a pinched wall that slowly rises as it reaches the corner. The south façade with its gently sloping wall holds the main entrance of the chapel.
- Weather/climatic conditions at Ronchamp

Before we get into more detailed analysis it is important to understand the climatic conditions present at Ronchamp.
3. Circulation/ Routes

Forms of paths

1.

2.

3.

south tower
Centralized

- Central, dominant space
- Secondary spaces

FLOOR PLAN

Visitors

Preacher

FLOOR PLAN
4. Spatial Configurations

The Exterior

“Outside: we approach, we see, our interest is aroused, we stop, we appreciate...” The visitor cannot get a good look at the chapel as he approaches at the south façade (side), but as he gets closer to the building he is immediately perceived by the heavy white mass consisting of a huge tower and an ascending big wall with irregular openings. The heavy looking roof stands out as it barely touches the end of the south wall, giving it a floating effect. The use of different colours is dominant to the eye, from the roof to the concrete entrance and finishing with the painted windows on the south wall.

The Interior

While entering the chapel from the north entrance the visitor’s attention is immediately drawn to the south wall but also to the choir on the east. “The south wall provokes astonishment” light changes according to the sun’s angle and as it is filtered through the thick south wall it creates a magical scene to the human eye.

The North Façade

The north façade consists of two functional spaces and two side chapels which can be located inside the two smaller towers. The towers are located facing west and east; the east capturing the morning light and the west capturing the sunset light with their calottes. Most of the openings serve the functional rooms but most importantly the openings on the north east corner work together with the openings on the east and south façade to create the ideal balance of light. This will be looked at in more detail further on.
**The west façade**

The west façade is the only wall present at the chapel with no openings. But it is a very important façade since it connects the south (big tower) with the smaller towers with a curved wall. A gargoyle is placed in the middle of the west façade, used for rainwater collection. Le Corbusier was very careful when he designed it since it sits at the stress point of a curve linking the two calottes in the north and south chapels. The height of the gargoyle is 4.52 metres “the modulor reduced to 4.52m=2x2.26m”.

**Main Door**

The main access to the chapel is through a large cast iron revolving door which is covered on both sides with a painting. Le Corbusier’s concept was while the door revolves it immediately conceives with the landscape communicating with the outside world. The smooth textured enamel paintings point out the use of the primary colours but as well as many of Corbs ideas and thinking, like natural shapes, trees, stars, hands and clouds.

**Outdoor chapel in the east**

The outdoor chapel is designed exactly the same as the interior. The facade and altar are mirrored to the outside to serve 10000 pilgrims as Le Corbusier wanted.
Interior scene facing east facade

The north towers
Exterior scenes

South entrance

Perspective view
North facade

East Facade
South wall
5. Construction / materials

The South wall construction: Focal area of investigation

Vertical triangular frames of reinforced concrete Modulor everywhere
The Shell Like Roof

(1a)

The North Towers

(1b)

1(c)
“Seven strong, flat beams 17cm thick all different” figure 1(b)

Between the south wall and the roof there is an opening of 10cm. Figure 1(c)
Materials:

Sprayed concrete used.
6. Ronchamp: A Light Machine, Sunrise to Sunset

One of the great accomplishments at Ronchamp is the precise planning of its various phenomena through time and space, to produce a totality of light in motion. The transition of light changes respectively as the earth rotates. When the first light comes up the east wall comes to life. The scattered holes behind the altar seem like stars in heaven, followed by a beam of sunlight on the floor. Gradually the light dissolves away, followed by an afternoon long illumination of openings in the south wall. The main concept behind the south wall is to capture different moments of the sun and this is accomplished by having all those openings orientating at slightly different directions. Openings are also adjusted in section to intercept the high summer sun, while allowing the low winter light through the wall and in the church. During this process the south tower receives the ambient north light through the filtering devices down to the chapel.
Diagram showing the sequence of the light devices from morning to sunset
7. The luminous environment at Ronchamp

Qualitative analysis:

Methodology

Ronchamp was visited on the 15\textsuperscript{th} of March of 2008. The sky conditions during my analysis were overcast and the measurements were taken between 12:00 – 1400 o’clock. Although some parts of the day the sky had cleared. Photometric measurements and sketches were conducted on site and spot measurements were conducted on selected positions as shown on figure ( ).

Equipment:  Hagner luminance & illuminance meter
Minolta illuminance meter

On site experience:

Figures 1-10 are sketches showing parts of the interior at Ronchamp.
More detailed observations are as follow:

1. Illuminace levels were quite low inside the chapel.
2. Illuminance levels on south wall varied a lot between each other mainly because of the different angles of the openings, depth of the wall but also the different colours on windows decreased or increased illuminance levels.
3. Illuminance level from South tower is equally balanced. No sign of glare.
4. Only one opening had significant illuminance level (close to glare). this was because at that specific time the sun was visible only from that specific opening. On that specific opening the glass was not clear but half opaque therefore reducing glare
5. Top half of Virgin Marys Statue was visible. Bottom half other was not visible. Bottom half was visible because an artificial light source was used to light the statue from the bottom. Surrounding surfaces are painted in different colour (primary colours)
Reference sheet: Spot Measurements
Various Sketches showing interior scenes
Reference (A)
Reference (C)
Reference (E)
Reference (F)
Reference (G)
Reference (H): Virgin Mary Statue
Reference (I): South Tower
Results and discussion:

Luminance Ratio

Photometric measurements were taken on site as indicated on the reference sheet. This was done in order to calculate the luminance ratio. In the CIBSE code for interior Lighting (1994) and in Daylighting by Hopkinson, the suggested ratio of task luminance to immediate surround to general surround should be in order of 10:3:1. By achieving this ratio then glare is avoided. The strong contrast between a light source and its background can often create glare.

Based on the summary explained below the luminance ratios on the south wall are normal, light is evenly balanced except reference F and this proves the fact that you don’t experience any glare. Light is evenly balanced as it penetrates the South wall.

Reference F (window F) had a much higher ratio than all the others. This was because at that specific time when the reading was taking the specific opening was facing directly at the sun. All the openings are orientated in slightly different directions in order to capture different moments of the sun at different times. This was Le Corbusiers main strategy for the south wall and reference F proves it.

Virgin Mary Statue

Baker’s recommendation for the luminance ratio when an object needs to be emphasized is recommended to be 50:1. Ronchamp is a chapel dedicated to Virgin Mary. At the Chapel there is only one Statue of Virgin Mary and Le Corbusier tries to emphasize that. We can see that the ratio for the Virgin Mary statue is 63:3:1. This again proves the fact that Le Corbusier did this on purpose in order to emphasize the importance of the statue. This is the only place with the highest contrast inside the church which makes it clear that the architect wanted to point out the significance of the statue.
Reference (I): South Tower

Based on the graph below we can see how light is evenly distributed from the top of the tower to the bottom. The eye operates over a large range of light levels. How the eye adapts from dark to light environments is very crucial. Human eye needs to adjust gradually to its surroundings. Le Corbusier manages to equally disperse light down the tower (see graph below) which helps the human eye to gradually adapt to its surroundings perfectly.

![Graph showing light distribution](image)

### Summary of Luminance Ratios on South wall

<table>
<thead>
<tr>
<th>Reference</th>
<th>Luminance Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10:1</td>
</tr>
<tr>
<td>B</td>
<td>5:2:1</td>
</tr>
<tr>
<td>C</td>
<td>15:3:1</td>
</tr>
<tr>
<td>D</td>
<td>10:3:1</td>
</tr>
<tr>
<td>E</td>
<td>3:2:1</td>
</tr>
<tr>
<td>F</td>
<td>40:3:1</td>
</tr>
<tr>
<td>G</td>
<td>10:1</td>
</tr>
<tr>
<td>H</td>
<td>63:3:1</td>
</tr>
</tbody>
</table>
Quantitative Analysis:

Methodology

A 1:50 scale model was build and tested on the heliodon in order to capture the transition of light (luminous environment) from sunrise to sunset. A video of the transition of light has been made which can be found on the cd provided. The video is mainly focusing on the south wall and south tower. The model was also used in the artificial sky to observe how light filters though the building. Daylight factor was also calculated and compared with the onsite measurements. Also different tests have been done in order to understand how light is evenly reduced in the chapel.

Daylight Factor (Site Measurement)

Usually the daylight factor is calculated in order to assess the daylight performance of a building. In my case Ronchamp is a chapel: a sacred place so the DF will not affect or change in any way my investigation on the luminous environment. The DF will be expected to be low since it is normal to have low illuminance levels in a church. Le Corbusier tried to reduce light as much as possible from all directions but at the same time tried to evenly balance it inside the building. A test was done to prove this. The onsite measurements for the DF were taken when the North door was deliberately left open. (see figure below) The readings taken on the physical model were taken with the door closed. A comparison was made.

North Entrance
Method for Daylight Factor Readings:

A grid was made 1 metre by 1 metre along the floor. When the readings were taken on site, sky was overcast. Lux measurement on the artificial sky were 1983 lux.
On Site Measurements

Daylight Factor Door Open: 0.6%, uniformity ratio 0.23%

Artificial Sky Measurements

Daylight Factor Door Closed: 0.33%, uniformity ratio 0.3%
Results and Discussion:

Daylight factor came out to be as low as expected. This is normal for a church environment. What is interesting is that the daylight factor when one door was fully opened was double the value than when closed. Ronchamp has many openings but because each one is manipulated in a unique way in order to reduce the amount of light entering, one single door when opened made a huge difference inside the space. As you can see from the graph above the blue line indicates lux levels when door is opened and red line when door is closed. Also notice how uniform light is through the space when the door is closed. Uniformity and balance of light is something that Le Corbusier craftily achieved.
Heliodon Study
Heliodon Study – Luminous environment

Luminous environment on the south wall using the Heliodon can be clearly seen in motion on the video provided. Winter, summer and equinox have been investigated thoroughly with pictures taken every half an hour starting from 6:00 in the morning until 18:00.
Winter: Luminous environment
summer: Luminous environment
Equinox: Luminous environment
Results and discussion:

Based on the heliodon results it seems that the most interesting season for Ronchamp is the winter season. The reason for this is that in winter we have full exposure to the sun (sun is lower) on the south wall which allows light to penetrate along the whole width of the chapel. Also for all seasons, winter, summer equinox, the most interesting times are when the sun rises in the morning and when the sun sets in the evening. Very cleverly Le Corbusier tried to keep the south wall quite constant from 11:00 o'clock in the morning until about 15:00 in the afternoon. This can be seen clearly on the pictures above and on the video provided. In the morning the East facade becomes alive and as the sun sets we can clearly see the change of luminance level on the south and north towers. There is no rapid change of light, light changes evenly, which explains how the architect managed to control the levels of light inside the building thus avoiding glare. Creating these kind of conditions the eye can easily adapt to the luminous environment thus creating perfect human comfort.

It is very clever how Le Corbusier uses the roof to shade the south wall in the summer. But he doesn’t shade it full. He allows light to penetrate only through the first row of openings on the south wall. This explains the architectural thinking on the south wall besides the Modulor. This explains why the south wall is 3 metres 70 thick at the bottom and 50 cm at the top. The first row of openings on the south wall is wider than all the others. And also this explains the sitting arrangement in Ronchamp. The seats are placed along the first row of openings to allow sufficient light for the worshippers.
Testing Luminous environment on north Tower

Figure (A) existing strategy

Figure (B) long strip blocked

Figure (C) devices removed

Figure (D) everything removed
Different tests have been done on the south tower in order to understand how Le Corbusier managed to keep the luminance ratio at the correct levels. The pictures below have been taken in the artificial sky. Having done a very accurate physical model actually helped capture Le Corbusier's design strategy.

In figure (A) the picture shows the luminous environment inside in real life conditions. The tower faces north so it receives north ambient light.

In figure (B) the long strip opening is blocked. Immediately we can observe how the luminance ratio increases.

In figure (C) the filtering devices are completely removed but the long strip is left open. We can see how the luminance ratio increases even more. In figure C we can distinguish the line separating the dark light from the bright light. We can no longer see the light gradually being diffused down the tower.

In figure (D) everything has been removed. We can clearly see the intensity of light has increased rapidly which creates an uncomfortable scene to the human eye. Adaptation of the human eye is very important. Even by looking at figure (A) and figure (D) we can distinguish the difference response to the eye. Figure (D) is too bright where as figure (A) is very smooth (eye calming).

Readings have been taken in the artificial sky using the luminance gun.

We can observe from figures 2 & 3 the difference in contrast and brightness as the openings in the tower are either blocked or completely removed. Figure (1) shows the real time luminosity levels and clearly we can observe a uniform distribution of light diffused along the surface wall. There is a 600 lux difference from normal conditions to the far extreme when light is fully absorbed in the tower.
Figure (1). Normal conditions

Figure (2) Long strip on tower is blocked: **reading 1000 lux**

Figure (3) Long strip opened, Devices removed: **Reading: 1600 lux**
8. Conclusion:

Figure (1)

Figure (2) (Francis Dk Ching P.173)
1. Ronchamp is a light machine that tries to reduce light from all the directions at all times of the day and at all days of the year. In order to achieve that it has different “light traps’ following the direction of the sun from sunrise to sunset. What’s fascinating is that whatever the devices are on the outside; they are exactly repeated on the inside but mirrored. This technique is a clever way for reducing light but at the same time diffusing it inside the sacred place. Besides Ronchamp is a church; a place to pray to god but at the same time someone must feel comfortable.

But how does Le Corbusier manage to have so many south facing openings but no glare? There are a lot of reasons, for example, the wall is 3 metres 70 thick at the bottom, also the openings are orientated at different directions blocking the suns beams and etc.

One final question and more significant is how does Le Corbusier manage to achieve perfect adaptation environments for the human eye; Because after all reducing glare can be one; but creating the right luminance environment for the human eye is another thing.

Well the answer is in figure (1) Figure (1) shows an interior shot showing different light sources at different directions. This is called asymmetrical balance. Figure(2 ) explains that the location of an opening is very important because it affects the manner in which natural sunlight enters a place. As Francis Dk Ching says but if the degree of contrast exists the brightness of the opening and the darker surroundings then glare will occur. But glare can only be reduced by allowing daylight to enter the space from at least two directions. Le Corbusier balances light by allowing diffused light to enter from all directions.
2. The roof design might have been very arbitrary but it plays a significant role to the luminance environment inside Ronchamp. It blocks the sun beams in the summer and it directs sunlight in the morning through the east entrance.

3. The light devices on the north east entrance are also doing a significant job towards the luminous environment since they (reduce) diffuse the light passing through. Figures b& c show the effect without the devices.
References:

1. Architecture, form, space and order, Francis DK Ching
2. Ronchamp chapel of light by Yves Bouvier
3. The chapel at Ronchamp: by Ezra Stoller
4. Le Corbusier and the chapel at Ronchamp
5. Le Corbusier Chapelle Notre Dame Du Haut, Ronchamp, France 1950-54 edited and photographed by Yukio Futagawa
6. Le Corbusier: architect Painter writer
7. Modulor 2 (1955) by Le Corbusier