Color and Colorimetry
Multidisciplinary Contributions

Vol. XX A

Edited by Filippo Cherubini and Andrea Siniscalco

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Piazza C. Caneva, 4
20154 Milano
C.F. 97619430156
P.IVA: 09003610962
www.gruppodelcolore.it
e-mail: segreteria@gruppodelcolore.org

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Introduction

The Color Conference, organized annually by the Italian Color Association (Gruppo del Colore - Associazione Italiana Colore), reached its Twentieth Edition in 2025.
The international two-day event took place on September 4th and 5th, 2025, at the University of Naples Parthenope in the beautiful city of Naples.

This milestone edition opened with three keynote presentations of exceptional breadth and inspiration. The conference began with Dr. Costanza Miliani from the CNR Institute of Heritage Science, who presented "Writing with Colors: Materials, Techniques, and Cultural Significance in Mesoamerican Codices". The program continued with Studio Waldemeyer, featuring Farahbod Nazanin and Moritz Waldemeyer, and their evocative talk "Where Light Becomes Emotion".
The morning session concluded with the Color Award 2025, conferred to Massimo Cantini Parrini in recognition of his extraordinary contribution to the world of costume and creativity.
The following day opened with an outstanding invited lecture by Dr. Massimiliano Guarnieri from ENEA, who presented "Artificial Intelligence and color features detection: some examples and future perspective".

Sincere thanks go to the Chairs of the Conference, Giuliana Ramella (CNR – Institute for Applied Calculus "Mauro Picone") Francesca Fragliasso (University of Naples Federico II) and Andrea Siniscalco (Dipartimento di Design, Politecnico di Milano), for their valuable guidance and coordination. A heartfelt appreciation also goes to the University of Naples Parthenope, host of this year's edition.
We warmly thank Dr. Sofia Ceccarelli (CNR ISPC) for the local organization, the Program Committee, Professors Angelo Ciaramella and Emanuel Di Nardo (University of Naples Parthenope), Professors Laura Bellia and Francesca Diglio (University of Naples Federico II), as well as Dr. Filippo Cherubini, Secretary of the Association, and all the members of the Scientific Committee, for their fundamental contribution to the dissemination, review, and organization of the conference. Special thanks also go to Tectilia, the event sponsor, whose support helped make this conference both culturally enriching and welcoming.

The 2025 program once again confirmed the richness and interdisciplinarity that have always characterized the work of our community, spanning from design to education, and from cultural heritage to psychology.
These diverse perspectives continue to make the Conferenza del Colore a reference point for researchers, professionals, and enthusiasts working on the multifaceted study of color.

Finally, we extend our gratitude to all authors and speakers for the quality of their contributions, and to the institutions and associations that offered their patronage and collaboration, reinforcing the spirit of unity that defines this event.

The following pages collect the proceedings of the Twentieth Color Conference.

We wish you an inspiring read.

Alice Plutino
October 2025

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Enhancing the neutral: white surfaces and luminous quality in the historic spaces of Villa Argentina

Franz Graf[1], Gianluca Guarini[2], Maurizio Rossi[3]
[1]USI – Università Svizzera Italiana
[2]Politecnico di Milano
[3]Politecnico di Milano
Contact: Gianluca Guarini, gianluca.guarini@polimi.it

Abstract

The USI Academy of Architecture in Mendrisio is housed in Villa Argentina, which offers a unique setting for investigating how natural light and white surfaces affect how historical spaces are perceived and enhanced. This article analyzes, through photographic documentation and illuminance measurements, aims to analyze how the predominance of white on the interior walls, combined with the villa's particular architectural configuration, influences the luminous quality, chromatic perception, and user experience. Despite their neutrality, the white walls transform into dynamic surfaces, allowing natural light to be reflected and diffused, increasing brightness and promoting an even distribution of light. This creates a sense of openness, lightness, and spatial continuity, making rooms more welcoming for office activities. The combination of white and natural light promotes user well-being, concentration, and a serene environment. The study emphasizes the importance of combining chromatic analysis and lighting technology to preserve and improve historic structures.

Keywords: Natural light; White interiors; Historic buildings; Architectural valorization.

Introduction

The quality of natural light and the color choice of surfaces represent two fundamental factors in the perception and enhancement of architectural spaces, particularly in historic environments intended for new functions. Villa Argentina, home to the USI Academy of Architecture in Mendrisio, is an emblematic example of how the predominance of white on the interior walls can interact with natural light to create welcoming, dynamic environments that are in continuous dialogue with the external context. Architectural literature has long recognized the central role of natural light as a "building material" capable of animating and transforming space. Light not only defines space but also imparts a perceptual, emotional, and, even “spiritual” character to it. "Space is oblivion without light" (Holl, 2006). Le Corbusier stated that "light creates the environment and the feeling of a place, just as it expresses a structure," highlighting the indissoluble link between light, form, and perception (Bathurst, 2020)

Recent studies have also shown that the reflectance of white surfaces increases the distribution and intensity of natural light, promoting a perception of openness and spatial continuity, and enhancing architectural details and materials (Espinoza-Sanhueza *et al.*, 2025). The relationship between light and color has been the subject of numerous experimental studies highlighted how the choice of materials and colors profoundly affects the luminous qualities and the psychophysical perception of environments (Makaremi *et al.*, 2019). In particular, the presence of white surfaces allows for a more intense perception of the variations in tone and temperature of natural light throughout the day, making spaces dynamic and ever-changing (Simm and Coley, 2011). Moreover, natural light carries the chromatic nuances of the external landscape into the buildings, enriching the perceptual experience and strengthening the dialogue between interior and exterior.

Through systematic photographic documentation and lighting measurements conducted during the central hours of the day, this article aims to explore how natural light is reflected and diffused by the white interiors of Villa Argentina, influencing the perception of spaces, the relationship between interior and exterior, and user comfort. The objective is to offer an integrated reading between

chromatic and lighting analysis, suggesting design and conservation strategies that can also be applied to other historical contexts where white and light neutral surfaces are present.

Fig. 1 – Villa Argentina

Historical-architectural context

Villa Argentina, located in Mendrisio in the Canton of Ticino, represents one of the region's most significant testimonies of nineteenth-century residential architecture. Designed by architect Antonio Croci between 1872 and 1873 on commission from Giovanni Bernasconi, an entrepreneur active in Argentina, the villa originally served as a summer residence. It is located at the foot of a hill within a large park rich in rare tree species, such as magnolias, Himalayan cedars, pines, and a two-hundred-year-old elm, which integrates the building into the greenery in a highly valuable natural setting (*Villa Argentina | ticino.ch*, 2025).

From a distributive point of view, the villa is developed over two above-ground floors plus a mezzanine, rising on a base that supports a double sequence of perimeter loggias. These loggias create colonnades surrounding the building on all sides, evoking Palladian geometries and simultaneously South American colonial architecture, a tribute to the client's experiences in Argentina. The floor plan is rectangular and enriched by a large central skylight, set on a circular drum, allowing natural light to penetrate the villa's heart and illuminate an internal helical staircase.

The interiors, now primarily characterized by white surfaces, have been adapted to the needs of the USI Academy of Architecture, which has occupied the villa since 1989 with the Direction, the Secretariat, administrative offices, logistical services, and various research institutes (*USI*, 2025). This functional transformation involved some modifications, such as the conversion of the original French doors into simple windows and the adaptation of spaces for academic use, while preserving the classical and exotic architectural and decorative elements, which together establish a relationship between the interior and exterior, enhancing natural light as a structural and perceptual element. The choice of predominantly white interior surfaces, in addition to meeting contemporary functional needs, enhances the brightness of the spaces and the chromatic dialogue with the external landscape, providing a foundation for a deeper reflection on the role of light and color in the perception of historic spaces.

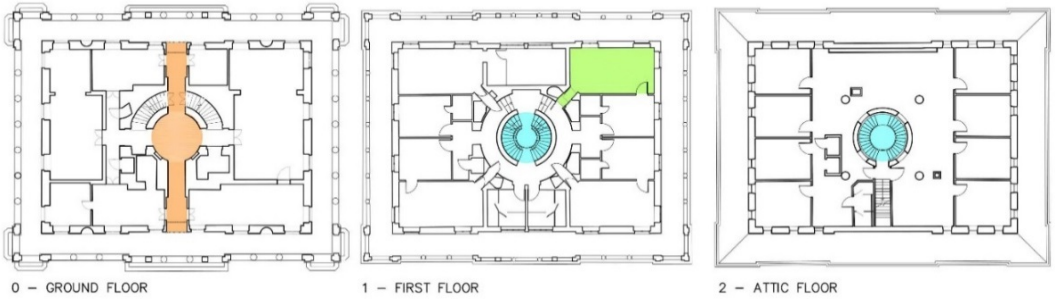

Fig. 2 – Plans of the Villa and areas involved in the photographic survey

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Methodology
The methodological approach adopted for the study of the interiors of Villa Argentina is based on the integration of photographic documentation and instrumental measurements of the lighting and chromatic conditions of the environments.

Photographic documentation
The photographic collection focused on three main areas of the villa, in different lighting conditions and from multiple viewpoints. Photography is recognized as a fundamental tool both for the preservation and for the study of the visual perception of architectural environments (Acar, 2018).


Fig. 3 – Photographic documentation of the atrium and corridor


Fig. 4 – Photographic documentation of the Director's office with interstitial space light by canon à lumiere


Fig. 5 – Photographic documentation of the main stairwell

Illuminance and spectrophotometric measurements
Parallel to the photographic documentation, illuminance measurements were taken in the same three representative rooms of the villa, selected based on their function, exposure, and architectural features. A lux meter was used to measure illuminance levels (expressed in lux), an instrument widely employed to evaluate the amount of light present in a space and its distribution. The measurements were conducted during the central hours of the day, when natural light reaches peak intensity and in most uniformly distributed in indoor environments, as recommended by CIE 117:1995 (Commission Internationale de l'Éclairage, 1995). In this specific case, the measurements were taken in these three situations. For the management offices on 17/7/2024 between 12:00 and 13:30. For the central staircase under the skylight on 24/7/2024 between 12:30 and 12:45. For the longitudinal corridor with the attached central atrium on 24/7/2024 between 13:30 and 14:15.

A spectrophotometer was also used to analyze the properties and quality of light in the management office. The combined use of a luxmeter and a spectrophotometer allowed for the correlation of

quantitative data on illumination with qualitative data related to the color rendering of surfaces, offering an integrated view of the perceptual conditions of the spaces.
The achieved illumination levels were compared with the standards required by the EN 12464/1: 2021 regulation "Lighting for work places – Part 1: Indoor work places" (‘UNI EN 12464-1:2021 - UNI Ente Italiano di Normazione’, 2021).

Geographical location, orientation of openings, angle of incidence of light:
In Fig. 6, the plan shows the position of the villa, its orientation, and the position of the windows/doors/loggias about the cardinal points and seasonal solar paths.
During the surveys, light fell on the three surveyed environments at an altitude of:

- 63.56° Directorate's office at 17/7/2024 - 155.71° azimuth
- 63.57° Atrium and Corridor at 24/7/2024 - 179.67° azimuth
- 61.49° Main stairwell at 24/7/2024 - 155.71° azimuth

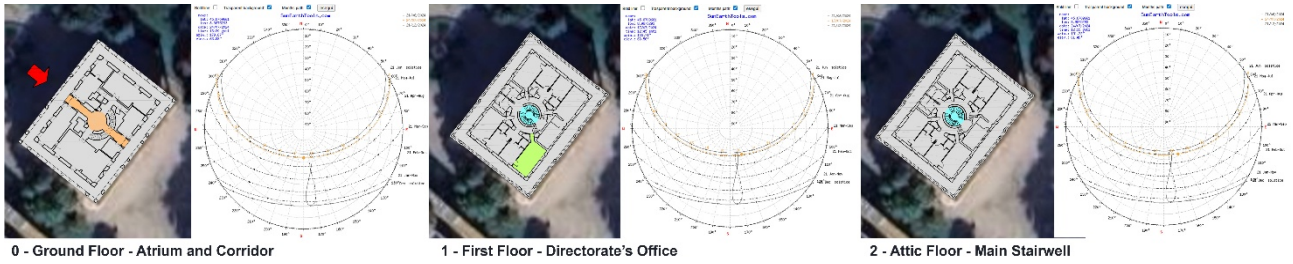


Fig. 6 – Orientation of openings on the ground floor and first floor concerning the North and corresponding solar diagram

Weather conditions:
The weather conditions at the time of the measurements were clear skies during the readings of the central stairwell, the corridor, and the central atrium on the ground floor. During the measurements in the directorate’s office, the weather conditions were variable and partially cloudy.

Correlated Color Temperature of light:
The color temperature was measured using a spectrophotometer in the directorate's office, with an average of 3 readings. The measurement of only natural light resulted in a value of approximately 5700K. The room was illuminated by natural light, but with the lighting fixtures turned on, the CCT was approximately 4800K. With only artificial light, the CCT was measured at 3300K once the blinds were lowered.

Characterization of white and relations with other material chromacity:
In a study on the restoration of the Villa (Graf and Nozza, 2024), where some solutions were developed to recover the original state of the paintings. Some alternatives were proposed regarding the historical solutions adopted initially in the environments, white paints were considered according to the NCS standard (Hård and Sivik, 1981). This standard is a color classification system based on human visual perception. The various shades are identified through codes that indicate color nuances and degrees of brightness. The final color is based on six primary colors (white, black, red, yellow, green, and blue), which, when mixed in different quantities, also allow for the distinction of various shades of white used in the paint industry.
The white detected in the villa's interiors is NCS S 0500N, a neutral white that is very close to pure white and without perceivable color dominants (the letter "N" stands for Neutral). It is a technical white, very similar to titanium white (titanium oxide - TiO_2), which is usually used to achieve pure and bright whites in paints. It does not have the warm tones of lime white nor the dusty ones of chalk:

it is cold, clean, and artificial, typical of modern or industrial contexts where a neutral and bright effect is sought. The NCS S 0500N white harmoniously matches the materials present in the building, such as the marble and stone of the main stairwell, the light marble of the corridors and atriums, and the warm parquet of the Directorate's office. Its neutrality enhances the natural veining of the stone surfaces and creates an elegant contrast with the wood, providing brightness and visual coherence to the environments. In Fig. 7, it is possible to observe a comparison between the detected color and other shades of white, along with the chromaticity of the other materials of the villa's interior.

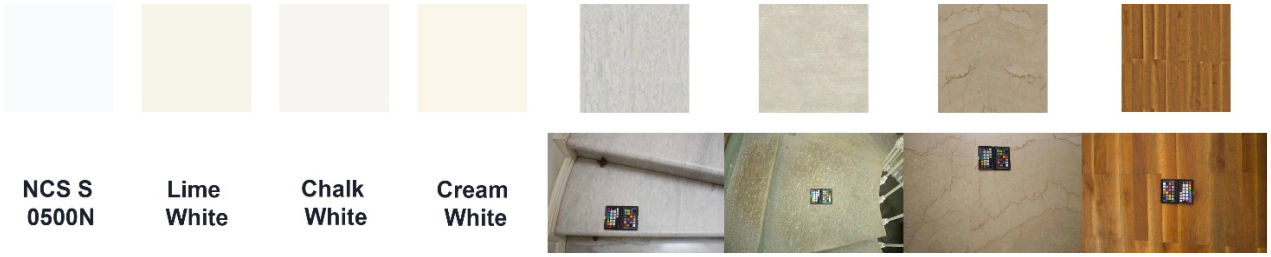


Fig. 7 – White NCS S 0500N and comparison with other whites

Results and Analysis

The collected data were analyzed with the aim of evaluating the distribution and intensity of natural light in the different areas. In particular, in the directorate's office, the influence of the presence or the absence of the bicolored striped curtain, which is part of the proposed guidelines for the recovery of the building, has been evaluated.

Distribution and quality of natural light in the Director's office

The measurements of illuminance and light quality were carried out using a spectrophotometer positioned at the center of the desk group in the management area.

Under conditions of only artificial light, the recorded values were: Em = 525 lux, CCT = 2889 K, and Ra = 84.

With the combination of natural and artificial light, the illumination increased to Em = 743 lux, with a correlated color temperature (CCT) of 3283 K and a color rendering index (CRI) of 89.

In the exclusive presence of natural light, the recorded values were Em = 198 lux, CCT = 4747 K, and Ra = 97.

Finally, with the use of external solar shading (lowered roller blinds) and natural light, the measured parameters were Em = 187 lux, CCT = 4855 K, and Ra = 98.

As reasonably expected, the quality of daylight, expressed through the color rendering index (Ra) (Bess, 1987), is significantly superior to that generated by the artificial lighting fixtures in the analyzed environment.

Distribution of natural light in the Director's office

The measurements taken with the luxmeter were conducted on the entire set of tables in the director's office using a grid of points, arranged according to the aforementioned EN 12464/1 standard. The results, shown in Figure 8, indicate that even under variable sky conditions, the average illumination required for working in Visual Comfort is not achieved if the external blinds, as stipulated by the restoration guidelines for restoring the original configuration of the loggias, are positioned lower. As specified by the regulations, visual comfort is intended as the work performance of users with normal or corrected ophthalmic visual capacity.

Distribution of natural light in the interstitial space "Canon à lumière"

The designer Antonio Croci has devised an ingenious system of 4 cylindrical chimneys that bring air and light to the rooms on the first floor, hallways, interstitial spaces between the offices, and the

circular corridor. It was therefore interesting to verify how much light these "canon à lumiere" actually brought.
Measurements taken in the center of the plexiglass surface, placed as a covering of the Canon à lumiere, gave 12 lux with a spectrophotometer, and a ground measurement of 3 lux in the center of the interstitial space with a lux meter. This results in a not very significant contribution of the light brought by the light duct inside the area, the neighboring management office, and the corridor.

Distribution of natural light in the main stairwell
For the stairwell, a grid of points was used, positioned on the surface of the individual steps, as shown in Figure 9. As specified by the regulations, the grid was designed to be rectangular and external to the circular shape of the staircase's outer profile. The average illuminance Em was found to be 11422 lux, well above the standard of 100 lux for passage areas, thanks to the presence of the large skylight at the top of the stairwell. The uniformity, on the other hand, was 0.31, lower than the 0.4 required by standards for spaces dedicated to this function. Probably the result was non-compliant because part of the staircase near the second floor was directly illuminated by sunlight.

Distribution of natural light in the central atrium and corridors
To measure the illuminance in the central atrium, which benefits from the light coming from the circular skylight on the roof, and in the two corridors that connect the central atrium to the north and south entrances of the villa, which benefit from the light coming from two respective French doors, a single grid of points was used. The results are, for simplicity, shown in three distinct zones. South Corridor, North Corridor, and Central Atrium, as shown in Figure 10, on a clear sky day, it was found that:
Central atrium - the average illumination Em was found to be 486 lux and the standard was met. The calculated uniformity was 0.37, slightly lower than the standard.
South Corridor - the average illuminance Em was found to be 701 lux, significantly exceeding the standard required by the regulations. The measured uniformity is 0.36, slightly below the standard.
North Corridor - the average illuminance Em was found to be 388 lux, also exceeding the standard here, despite the north exposure. In this case, the standard requirement regarding Uniformity was also met.
The use of NCS S0500N white paint, along with the presence of the large central skylight and the connection with the central atrium and the two longitudinal corridors, has allowed for the satisfaction of Visual comfort standards with only natural light on a day with a clear sky during the central hours of the day.

Conclusions
This study on Villa Argentina in Mendrisio, home to the USI administrative offices, demonstrates how using a bright neutral white—specifically NCS S 0500N—combined with thoughtful architectural design, promotes the effective entry and uniform diffusion of natural light throughout the building. Thus, the users' visual comfort is improved, enhancing the workers' quality of life and well-being. Even if uniformity has not always been fully achieved, the use of large skylights and French windows has increased the amount of light reflected on white surfaces. The loggias and the curtains that were originally installed limit the direct sunlight, thereby reducing glare for users while still providing high-quality indirect lighting for them. These results, which are supported by photographic documentation and lighting surveys, are useful for providing methodological insights for the restoration and conservation of other historic buildings, where natural light, in combination with architecture and colors, can create welcoming and functional spaces.

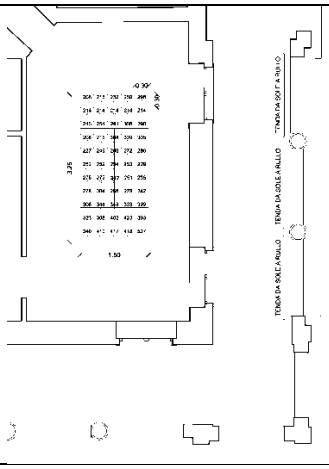
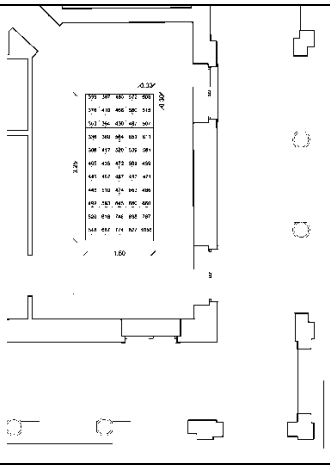
Directorate's office - Detection height = table surface	
roller blinds in the lowered position AVERAGE ILLUMINANCE Em = 293 lx (Standard = 500 lx) Emin = 208 Emax = 527 UNIFORMITY Uo = 0.71 (Standard = 0.6)	roller blinds in the raised position AVERAGE ILLUMINANCE Em = 536 lx (Standard = 500 lx) Emin = 336 Emax = 1056 UNIFORMITY Uo = 0.63 (Standard = 0.6)
	

Fig. 8 – Distribution and natural light in the Director's office

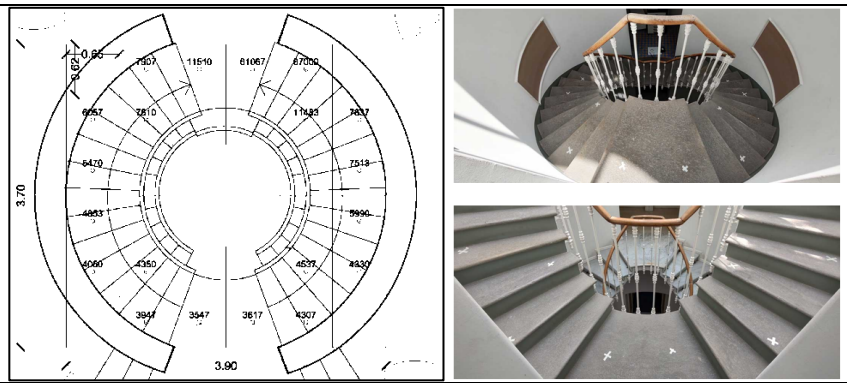
The main stairwell
AVERAGE ILLUMINANCE Em = 11422 lx (Standard = 100) Emin = 3547 Emax = 67000 UNIFORMITY Uo = 0.31 (Standard = 0.4)


Fig. 9 – Distribution and natural light in the main stairwell

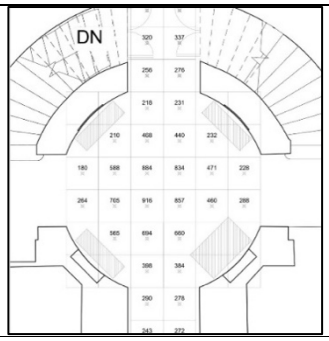
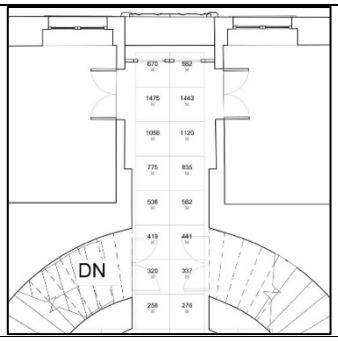
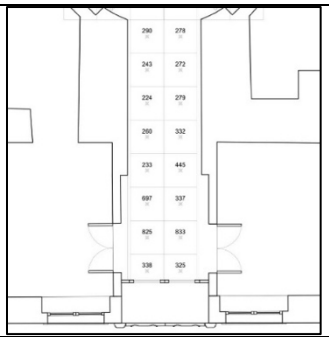
Central atrium	South Corridor	North Corridor
AVERAGE ILLUMINANCE Em = 486 (Standard = 100) Emin = 180 Emax = 916 UNIFORMITY Uo = 0.37 (Standard = 0.4)	AVERAGE ILLUMINANCE Em = 701 (Standard = 100) Emin = 256 Emax = 1475 UNIFORMITY Uo = 0.36 (Standard = 0.4)	AVERAGE ILLUMINANCE Em = 388 (Standard = 100) Emin = 224 Emax = 883 UNIFORMITY Uo = 0.58 (Standard = 0.4)
		

Fig. 10 – Distribution and natural light in the central atrium and corridor

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