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Investigation of Lighting Conditions and Visitors' Satisfaction in Exhibition Spaces of Museums in Korea - Focused on the 4 Cases of the Seoul Museum, the Mimesis Art Museum, the Seoul Museum of Art in Nowon and the National Museum of Modern and Contemporary Art in Gwacheon -

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ABSTRACT

Museums have developed various needs of the visitors and exhibits over the past two centuries. Currently, they have multiple functions of display, conservation, research and public education about artworks and cultural events. Therefore, exhibits should be displayed in various ways so that visitors can feel inter-relations with exhibits. The exhibition areas of museums should be provided with the stable lighting environment for visitors and artworks. For the study, I selected four museums, which were the Seoul Museum, the Mimesis Art Museum, the Seoul Museum of Art in Nowon and the National Museum of Modern and Contemporary Art in Gwacheon, and I measured illumination levels of the selected Museums, and then, I surveyed the visitors' responses on the lighting conditions of them. According to the results, the measurements of the illumination levels in the four museums showed that the illumination levels of them were effectively controlled to display the art works. However, the illuminance levels at some areas that drew the natural light as lighting source were much higher than recommended illumination values for museum. In the mean time, the answers of questionnaires showed that the natural light were so effective to light the museums although the natural light provided some areas with high illumination levels.

KEYWORD

Museum
Exhibition Space
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1. Introduction

1.1. Background and Purpose of the Research

The role of a lighting in an art museum is to sufficiently reveal the beautiful properties of an artwork and provide acceptable illuminance value for the viewers, at the same time, conserving the artworks. Moreover, museum lighting should promote enjoyment of the artwork and relieve fatigue of the eye. Thus, the illumination value in an exhibition space becomes a critical aspect of exhibition planning. In that, lighting has to consider both the qualitative and quantitative elements, and, for architects and lighting engineers, the integration of natural and artificial light should be considered the principle of art museum lighting.

Peter Wilson[1] proposed a way to create a museum lighting environment that achieves a smooth transition of natural and artificial lighting. He suggested on exploring the changing properties of natural light, due to changes in the season or by time of the day, and applied this changes to control the artificial lighting. As a result, his proposition was able to demonstrate the integration of two different light sources, while providing both psychological and visual comfort of the viewers. Jack V. Miller[2] also addressed that the principles of museum lighting are beautiful presentation of the artworks, conservation of the works from the exposure of light radiation, and energy saving and cost-cutting conservation methods. Mary Claire Frazier[3] advised on utilizing the light source that implemented energy sufficiency and cost-cutting measures. G. Pavlogeorgatos[4] recommended a system that controlled museum's environment. The environmental elements were humidity, air pollution substances, noise and vibration pollution, temperature and lighting. Furthermore, regarding the conservation of the artworks, he underlined the importance of conserving the artworks from discoloration or degradation due to the ultraviolet rays emitted from the natural and artificial light source. Julio M. del Hoyo-Meléndez, et al[5] measured the amount of accumulated illuminance level in an exhibition space over a period of a year, and produced a useful evaluation method that could minimize the light radiation damage. C.W. Kenner pointed out that the fundamental elements of perception in a museum are the control of daylight and glare problem, conservation of the artworks, visual impression of the exhibition space and displayed artworks, and form of the artworks.[6]

For this research, I has selected four major museums located near Seoul for studying the exhibition environment, and then, analyzed the effect of lighting for the viewer, and thus, tried to

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accumulate primary data for museum design.

1.2. Methodology and Limitations

The present study has selected two public museums (National Museum of Modern and Contemporary Art in Gwacheon and Seoul Museum of Art in Nowon) and two private museums (Seoul Museum and Mimesis Art Museum). The illumination levels of their exhibition spaces were measured, and survey was made to research the visitors' satisfaction according to the different illuminance value at each museum. This research was conducted as follows:

First, the illuminance value acting as a decisive perception component to create the exhibition environment, the recommended domestic and international illuminance values were examined.

Second, a comparative analysis was made between the measured illuminance values of the four selected museums and the recommended illuminance values for museum.

Third, at the same time, a survey of viewer's satisfaction about the exhibition space and its relationship to the illuminance value was conducted, and the result was examined using the SPSS software.

Fourth, by analyzing museum illuminance value and viewers' satisfaction, the research accumulated primary data necessary for museum design.

2. Examination of Recommended Illuminance Value for Museum

2.1. Recognition of Objects in an Exhibition Space

Lighting in an exhibition space has to sufficiently reveal the innate beauty of the artworks to the viewer. This does not merely indicate the ability to distinguish form or color of the works, but lighting needs to display the work in totality. From a psychological perspective, in regard to recognition, the object is most naturally realized by our brain when there is a simplest system between the object and the viewer. Moreover, humans are only able to predict their subsequent action when they are fully aware of the space that they are in.

Due to the nature of our vision, the central vision has to maintain a ratio of 1:3 in luminance contrast, and the luminance contrast ratio between the central and peripheral vision should not be more than 1:10.

2.2. Recommended Illuminance Value for Exhibition Space

The exhibition space has to maintain an illuminance appropriate for the viewers and artworks. Meanwhile, it has to sustain an enough illuminance value to reveal the relationship between the artworks, the artwork and its background, as well as, the overall exhibition space. In order to achieve an equal atmosphere, the minimum illuminance of the general lighting cannot exceed 0.8 below the standard illuminance value. Furthermore, in a same space, the general illuminance should not be lower than 1/3 of illuminance of the display area. Also, the general illuminance of the neighboring spaces should not exceed a ratio of 1: 5.[9] The illuminance values recommended by Illuminating Engineering Society(IESNA) according to the purpose and function of particular spaces are shown in <Table 1>.[10]

Table 1. Illuminance values for generic types of activity(IESNA)

Illuminance values for generic types of activity in interior		
Type of Activity	Illuminance	Work-Plane
Public space with dark surroundings	20 -30 -50	General lighting
Simple orientation for short temporary visits	50 -75 -100	
Working spaces where visual tasks are only occasionally performed	100 -150 -200	
Performance of visual tasks of high contrast or large size	200 -300 -500	Illumination on task
Performance of visual tasks of mean contrast or small size	500 -750 -1,000	
Performance of visual tasks of low contrast or very small size	1,000 -1,500 -2,000	

Table 2. Recommended illuminance limits considering exhibits'damages by lighting exposure (unit: Lux / Lux・h per year)

	ICOM	IESNA (USA)	CIBSE (UK)	JIS (Japan)	MMFA (Canada)	KS (Korea)
Highly susceptible: silk, textiles, watercolors, furs, lace, etc	50	54 / 54,000	50 / 150,000	75 ~ 300	75 / 12,000	150 ~ 300
Moderately susceptible: oil painting, leather, wood, etc	150 ~ 180	220 / 500,000	200 / 600,000	300 ~ 750	100 / 42,000	300 ~ 600
Least susceptible: metal, glass, ceramic, stone, jewelry, etc	-	-	-	750 ~ 1500	100 / 84,000	600 ~ 1500

Lighting could be considered one of the most essential elements of an exhibition environment, thus it has to provide well suited lighting condition for the viewers to enjoy artworks and eliminate the possibility of damaging the artworks. Various countries have regulated illuminance value based on the photochemical degradation of ultraviolet rays, and divided the artworks into the following categories considering their damages by lighting exposure; highly susceptible to light, moderately susceptible to light and least susceptible to light. <Table 2> shows the recommended illuminance limits and display duration of the artworks used by Illuminating Engineering Society (IESNA), Chartered Institution of Building Services Engineers (CIBSE) and Montreal Museum of Fine Arts(MMFA) according to the annual accumulation of illuminance.

3. Analysis of Illuminance Values in the Selected Museums

3.1. Museum Selection to Measure Illuminance Values

The selection of museums were made according to the architectural design, competence of exhibition environment, and their popularity amongst the museum goers. Also, they were four museums near Seoul that had different methods of lighting. Among the four museums, Mimesis Art Museum and Seoul Museum of Art in Nowon fully incorporated the natural and artificial lighting for the exhibition space, and Seoul Museum and National Museum of Modern and Contemporary Art in Gwacheon utilized artificial lighting. The summary of selected museums are provided in <Table 3>

The horizontal illuminance value was measured 1 meter above the floor with illuminance meter manufactured by Minolta, <Fig. 1, Fig. 2> The measurements were conducted from May 31, 2014 to June 15, 2014.

Table 3. Characteristics of Selected Museums

Name	Seoul Museum (SM)	Mimesis Art Museum (MAM)
Building View		
Architect	Yeo Hyun Architects	Alvaro Siza
Size	8,650 m^2	3,636 m^2
Name	Seoul Museum of Art in Nowon (SMA)	National Museum of Modern and Contemporary Art in Gwacheon (NMMCA)
Site Plan		
Architect	Samoo Architects	Kim Tae Soo
Size	17,110 m^2	34, 006 m^2

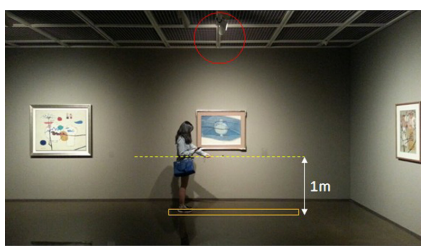


Fig. 1 Measurement Height

Fig. 2 Illuminance Meter

3.2. Analysis of Measurements in the Selected Museums

(1) Seoul Museum(SM)

a. Architectural Characteristics

SM is a private museum in Seoul, and it is a four story building with three ground floors and a basement floor. The basement level has a duty free shop and a cafe, the first and second levels are exhibition spaces, and the third level is used as an auditorium or for seminars. Also, the third level is connected to Sukpa-jung, which was used as a summer house of Huengsung-gwun. The exhibition space begins on the first floor and extends to the second floor, and the circulation of the building is designed with consecutive passages. <Fig. 3, Fig. 4>

Fig. 3 Exhibition room in 1st floor

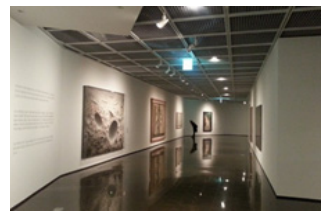


Fig. 4 Exhibition room in 2nd floor

b. Analysis of the Lighting

The exhibition areas was illuminated with only artificial lighting. The first floor was displaying paintings, sculptures, and porcelain. The second floor was presenting Joongsup Lee and other modernist paintings as a permanent exhibition. The horizontal illuminance values were measured in 77 points on the first floor and 64 points on the second floor. <Fig. 5>

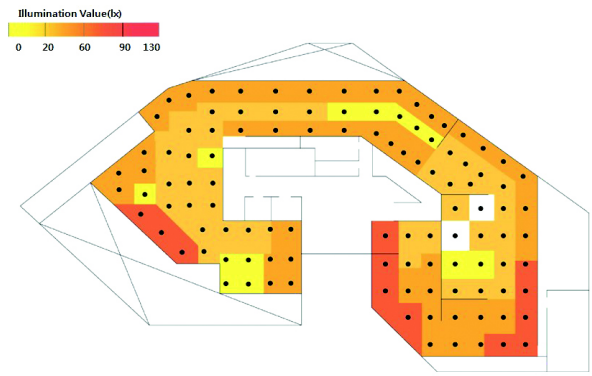


Fig. 5 Illuminance Distribution on the Second Floor

According to the results, illuminance distribution on the first floor was maximum 129 Lux, minimum 7 Lux and average 45 Lux. n the second floor, the maximum illuminance value was 134 Lux, minimum 2 Lux and average 56 Lux. Also, there was no noticeable difference of illuminance values between the spaces that displayed different genre of artworks.

(2) Mimesis Art Museum(MAM)

a. Architectural Characteristics

MAM is a four story building with three ground floors and a basement floor. The exhibition space is located on the first and the third level, and the second level is occupied by offices or left empty. The white exhibition spaces have various curved surfaces. They drew in as much natural light as possible to present a calm viewing space, and avoided the use of artificial lighting.

Most exhibitions held in this museum were temporary exhibitions, and various genre of art, such as painting, animation and sculptures, were displayed according to the exhibition objectives. The first floor exhibition hall<Fig. 6> utilized both indirect artificial lighting and natural light from a window. The empty space on the second floor were lit by natural light that flowed from the skylight all the way to the first floor hall. <Fig. 7> The third floor exhibition space did not use any artificial light and lit the artworks only with the natural light that flowed from windows and skylights. Horizontal panels were constructed under the ceiling to block and spread the direct sunlight. <Fig. 8> <Fig. 9>

Fig. 6 Sidelight on the first floor

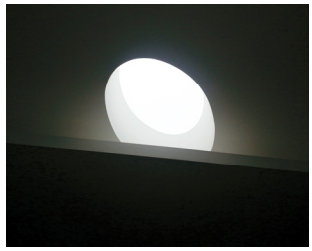


Fig. 7 Circular shaped skylight

Fig. 8 Side light in third floor

Fig. 9 Toplight on the third floor

b. Analysis of the Lighting

The horizontal illuminance levels were measured in 78, 24, 80 points respectively on the first, second, third floor.<Fig. 10>

According to the results, illuminance distribution on the first floor was maximum 757 Lux, minimum 130 Lux and average 239 Lux. On the second floor, the maximum illuminance value was 168 Lux, minimum 81 Lux and average 133 Lux. Lastly, on the third floor, the maximum illuminance value was 892 Lux, minimum 260 Lux and average 540 Lux. These data showed that the exhibition spaces of the first and second floors were lighting with high level of illuminance.

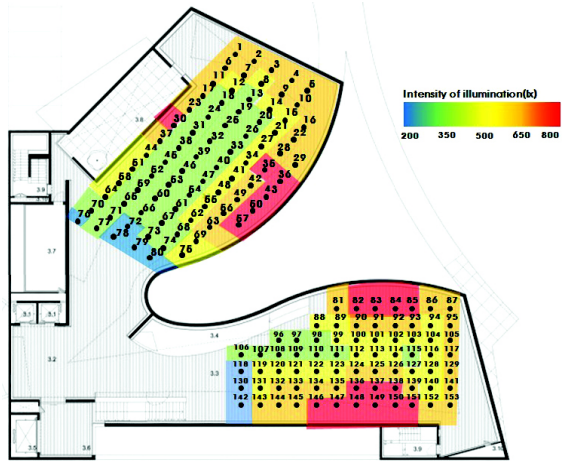


Fig. 10 Illuminance Distribution on the 3rd Floor

(3) Seoul Museum of Art in Nowon(SMA)

a. Architectural Characteristics

SMA is located in neighborhood park surrounded by high apartments. It is a six story building with three ground floors and three basement floors. A children's gallery is located on the first basement floor and displays participatory sculptures that could intrigue children. On the first and second floor, there were temporary exhibition spaces that were displaying photography, calligraphy and painting. The exhibition areas on each floor was lit by the artificial and natural light.<Fig. 11~13>

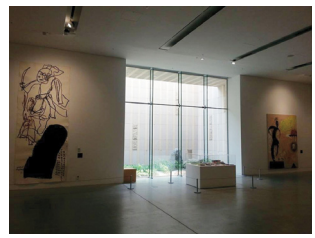


Fig. 11 Sidelight on the 1st floor

Fig. 12 Sidelight on the 1st floor

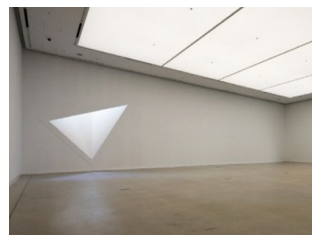


Fig. 13 Sidelight on the 2nd floor

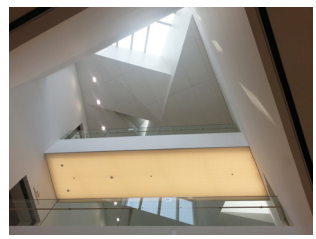


Fig. 14 Toplight

The natural light from windows led a circulation for the viewers to follow and amplified the visual pleasure within the exhibition space. Furthermore, the natural light from the skylight <Fig. 14> was also used as a general lighting for the children's gallery and the lobby.

b. Analysis of the Lighting

The horizontal illuminance levels were measured in 60 points on the first gallery of the first floor, 15 points on the first photography gallery of the first floor, 55 points on the second gallery of the second floor and 12 points on the second photography gallery of the second floor.<Fig. 15>

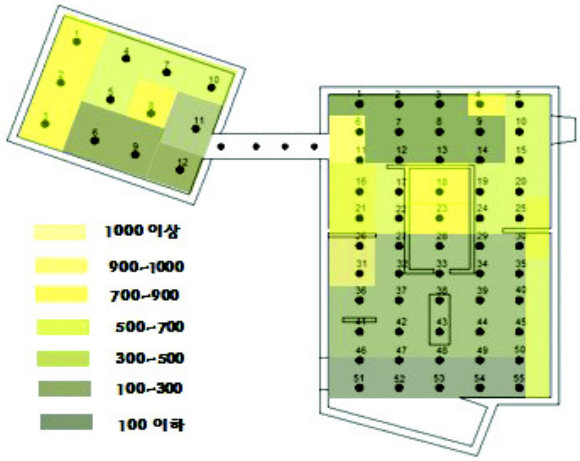


Fig. 15 Illuminance Distribution on the Second Floor

According to the results, illuminance distribution on the first gallery of the first floor was maximum 791 Lux, minimum 14 Lux and average 272 Lux. On the first photography gallery of the first floor, the maximum illuminance value was 1,971 Lux, minimum 1,089 Lux and average 1,439 Lux. On the second gallery of the second floor was maximum 663 Lux, minimum 44 Lux and average 305 Lux. Lastly, on the second photography gallery of the second floor, the maximum illuminance value was 675 Lux, minimum 210 Lux and average 450 Lux. These data show that the exhibition spaces were lit with high level of illuminance.

(4) National Museum of Modern and Contemporary Art in Gwacheon(NMMCA)

a. Architectural Characteristics

NMMCA is a four story building with three ground floors and a basement floor. Along with the main lamp core located at the central hall of the museum, the first level is connected to the second and the third level. Also, on the left of the lamp core is a circular exhibition space and on the right is the main exhibition space such as the temporary exhibition space and children's museum.

Mainly, artificial lighting was used in various ways according to the exhibition objectives and its genre. It was design to allow natural light into the lamp core, atrium of temporary exhibition area and children's museum. However, the skylight of the atrium was closed off to prevent the possible degradation of artworks by the natural light. The first floor has the first circular gallery, the first and second gallery. The second floor has the second circular gallery, the third and fourth gallery. The third floor has the fifth and sixth gallery. <Fig. 16~19>

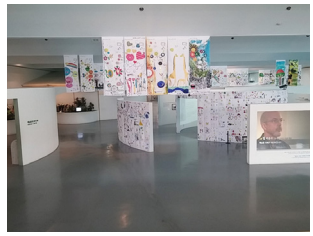


Fig. 16 Children gallery

Fig. 17 Circular gallery No. 1

Fig. 18 Atrium

Fig. 19 Gallery No. 1

b. Analysis of the Lighting

To measure the illuminance value of the exhibition spaces, 7 points on the circular gallery, 7 points on the children's gallery and 6-12 points were selected on the different temporary exhibition galleries.<Fig. 20>

According to the results, illuminance distribution on the children's gallery that displayed chemical artworks and sculptures was maximum 284 Lux, minimum 264 Lux and average 276 Lux. On the first circular gallery displaying multimedia, the illuminance distribution was maximum 140 Lux, minimum 116 Lux and average 128 Lux, and at the second circular gallery displaying metal-smithing works, it was maximum 181 Lux, minimum 152 Lux and average 168 Lux. The first gallery, for temporary exhibition, was showing metal sculptures, and the illuminance distribution was maximum 363 Lux, minimum 327 Lux and average 335 Lux. The second gallery was showing ink paintings, and maximum illuminance was 183 Lux, minimum 172 Lux and

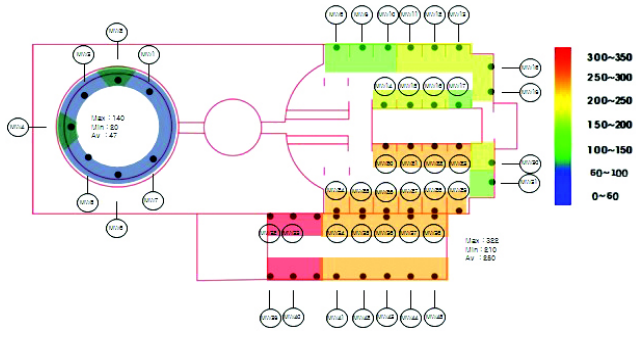


Fig. 20 Illuminance Distribution on the First Floor

average 181 Lux. The third gallery was not ready for public viewing, and so no measurements were not gathered. The illuminance distribution of the fourth gallery showing oil painting was maximum 171 Lux, minimum 141 Lux and average 155 Lux. The illuminance distribution of the fifth gallery showing architectural works was maximum 67 Lux, minimum 60 Lux and average 63 Lux. Lastly, the illuminance distribution of the sixth gallery showing photography was maximum 128 Lux, minimum 108 Lux and average 117 Lux. The data revealed that exhibition lightings were controlled suitable to the contents of the exhibition.

3.3. Summary of Measurement Results

<Table 4> illustrates the illuminance value data along with the exhibited artworks of the museums. According to the analysis, SM and NMMCA satisfied the recommended illuminance values for museums. However, MAM and SM were given higher illuminance than recommended.

According to the results, SM and NMMCA could easily control illuminance levels of exhibition areas by using artificial lights, while MAM and SMA did not fully control the natural light flowing from the windows and skylights. Therefore, further studies are needed to secure stable lighting environment and prevent the photochemical reactions and degradation of the artworks.

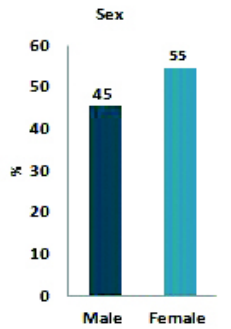
Table 4. Measured illuminance of selected museums: (unit: Lux)

	Floor	Exhibits	Maximum	Minimum	Mean
Seoul Museum (SM)	1st	Painting Sculpture Pottery	129	7	45
	2nd	Painting	134	2	56
Mimesis Art Museum (MAM)	1st	Cartoon	757	130	239
	2nd	Sculpture	168	81	133
	3rd	Painting	892	260	540
Seoul Museum of Art in Nowon (SMA)	1st	Painting Photograph	791 1,971	14 1,089	272 1,439
	2nd	Painting Photograph	663 675	44 210	305 450
National Museum of Modern and Contemporary Art in Gwacheon (NMMCA)	1st	Painting Sculpture for children	284	264	276
		Digital	140	116	128
		Metal	181 346	153 327	168 335
		Oriental painting	183	172	181
	2nd	Painting	171	141	155
	3rd	Architecture	67	60	63
		Photograph	128	108	117

4. Satisfaction of Viewers on Lighting Environment

4.1. Research Subjects and Methodology

The survey was conducted to find out the visitor's satisfaction according to the different lighting environment of the selected museums. Likewise to the illuminance measurement, the survey was also conducted from May 31, 2014 to June 15, 2014. The respondents were 50, 90, 90 and 41 persons respectively from SM, MAM, SMA and NMMCA. Thus, in total, there were 271 participations (male: 123 persons, 45% and female: 148 persons, 55%). <Fig. 21, 22>



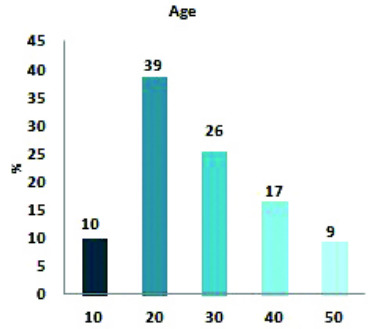


Fig. 21 Sex of Respondents *Fig. 22 Age of Respondents*

Table 5. Contents of Questionnaire

Category	Contents
Respondents	• Sex and Age
Architectural Design	• Design Factor for Museum • Environmental Considerations for Museum
Lighting Condition	• Visitors' Satisfaction on Lighting Condition • Glare Problem in Museum • Visitors' Satisfaction on natural Light

The results of this survey was examined using the SPSS software. Survey contents are provided in <Table 5>.

4.2. Analysis of Survey Results

(1) Design Elements that Effect the Viewing

In order to find out the architectural design elements that effected the viewer's satisfaction in a museum, a survey was conducted and analyzed. <Fig. 23> The options for questionnaire included size of the exhibition space, method of display, duration of exhibition, circulation route, exhibition environment, and resting area.

The results that participants from each museum chose as the most important design elements for museums were as follows; from SM, method of display (15 persons: 30%), exhibition environment (14 persons: 28%) and circulation route (13 persons: 25%); from MAM, circulation route (32 persons: 36%), method of display (29 persons: 32%) and exhibition environment (21 persons: 23%); from SMA, method of display (47 persons: 52%), circulation route (18 persons: 20%), from NMMCA, circulation route (23 persons: 56%) and size of the exhibition space (14 persons: 34%)

Moreover, looking into the results of all 271 participants, method of display (35%) and circulation route (32%) were selected

as the most important design elements, and then selected exhibition environment (15%), size of the exhibition space (11%), duration of exhibition (5%), and resting area (3%) as the order of importance.

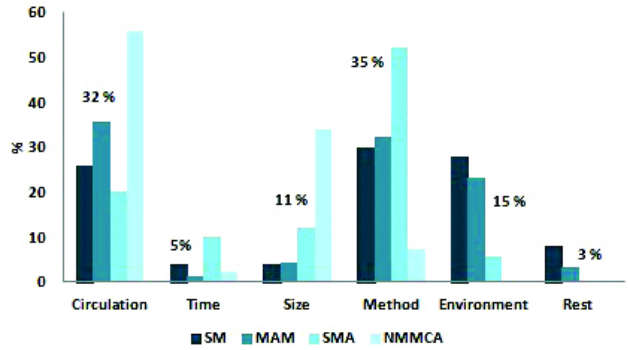


Fig. 23 Architectural Design Factors for museums

(2) Environmental Factors that Effect the Viewing

<Fig. 24> illustrates the analysis of interior environments that effect the viewing satisfaction of the visitors. The options for questionnaire included temperature, lighting, ventilation, noise, humidity and color.

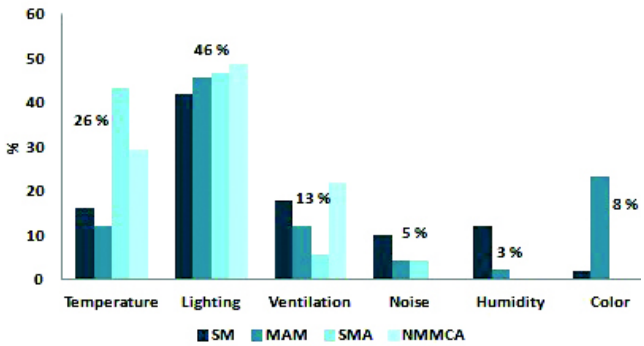


Fig. 24 Environmental Factors for museums

The results that participants from each museum chose as the most important interior environments for museums were as follows; from SM, lighting (41 persons: 46%) and ventilation (9 persons: 18%); from MAM, lighting (41 persons: 46%) and ventilation (11 persons: 12%); from SMA, lighting (42 persons: 47%) and temperature (39 persons: 43%), from NMMCA, lighting (20 persons: 49%) and temperature (12 persons: 29%). Moreover, looking into the results of all 271 participants, lighting (46%) and temperature (26%) were selected as the most important interior aspects to consider, and then selected ventilation (13%), noise (5%), and humidity (3%) as the order of importance.

(3) Satisfaction of Lighting Environment

This study surveyed about the viewer's satisfaction on one of the main elements of art appreciation, which is the lighting environment. The complied data is organized in <Fig. 25>.

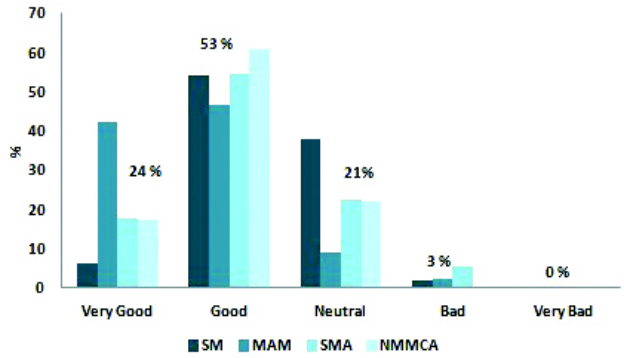


Fig. 25 Satisfaction of Lighting Condition

According to the analysis, 77% of the participants were satisfied with the museums' lighting environment, and only 3% were dissatisfied. This result reveals that lighting environment of the selected museums delivered high level of satisfaction for the viewers.

(4) Glare

The survey questioned about the glare problem in the selected museums, which can effect the qualitative satisfaction of the viewing. The data is presented in <Fig. 26>. According to the results, 59% of the participants did not notice any glare problem, 18% experienced the glare problem. However, 58% of the participants from NMMCA noted that they experienced the glare problem, the result of which showed a contrasting result with the results of the other museums. It is because general illuminance level of NMMCA was given in relatively low distribution, thus causing glaring to occur more often.

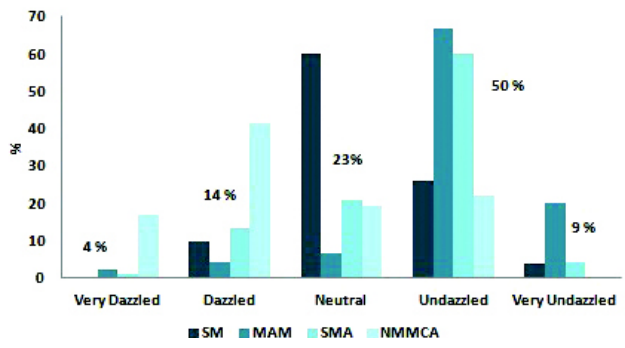


Fig. 26 Visitors' Perception against Glare Problem

(5) Preference of Natural Light as a Lighting Source

<Fig. 27> was organized the results of the participants' reactions on the use of natural light in a museum. According to the results, 69% of the participants responded that the use of natural light helped the viewing and 8% answered it was unnecessary. This

result showed very positive reaction to the use of natural light in the exhibition spaces.

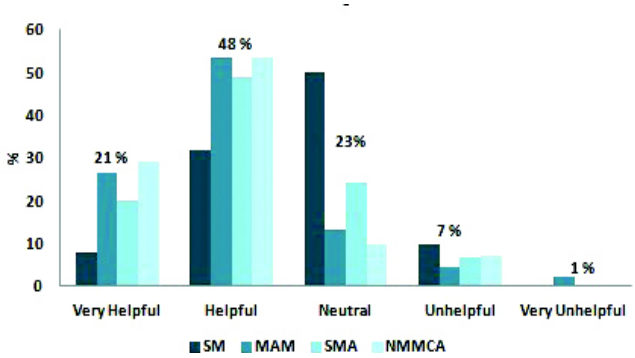


Fig. 27 Visitors' Responses on Natural Light

Positive answers of MAM and SMA on the use of natural light as a lighting source, which were lighting exhibition spaces with natural light, were 80% and 79%. Positive answers of SM and NMMCA, which were lighting exhibition spaces with only artificial lights, were 40% and 83%. It was interesting that the participants of NMMCA responded very positively on using the natural light as a lighting source, which has been providing more stable lighting by controlling the artificial light.

4.3. Summary of Survey Results

From the above survey results, participants selected method of display and circulation route as the most important design elements for museums, and selected lighting as the foremost important factor of the exhibition environment. Furthermore, most of the participants answered positively on using natural light as a lighting source. In particular, most participants of NMMCA agreed on the need for natural lighting, which has been providing more stable lighting using the artificial light source. Hence, further study is necessary to examine the environmental factors that can effect the viewing of the visitors.

5. Conclusion

This research selected four museums to study the exhibition environment, and measured the illuminance values and surveyed viewer's satisfaction according to the lighting environment. Thus, the present research aimed to compile primary data that could be utilized in the design phase for museum. The following is a recapitulation of this study.

Considered one of the most important aspects of exhibition environment, the museum lighting has to provide sufficient illuminance for visitors to view the artworks, as well as, to prevent degradation of the works. Therefore, a re-examination of domestic light limits for museums is required to fully regulate illuminance values and duration of the exhibition by considering the photochemical degradation of the materials of the artworks.

According to the analysis of measurements in the selected museums, SM and NMMCA could easily control illuminance levels of exhibition areas by using artificial lights, while MAM and SMA did not fully control the natural light coming from the windows and skylights.

In regard to the survey evaluating viewer's satisfaction to the lighting environment, participants stated that lighting was an essential factor for the exhibition space and answered very positively to the use of natural light as a light source of museum.

Further study is necessary to examine the environmental factors that can effect the viewing of the visitors, and apply them to the design process of museum.

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