SCIENCE SET
OPEN ACCESS PUBLISHERS

ISSN: 3067-929X
Research Article

Journal of Electronics Science and Electrical Research

Assessing Daylighting Performance and Visual Comfort of Shopping Malls in the Province of Cavite, Philippines

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Submitted: 18 July 2025 **Accepted:** 23 July 2025 **Published:** 30 July 2025

https://doi.org/10.63620/MKJESER.2025.1015

Citation: *Gutierrez, S. M. Y., Garing, A. N. D., Pernia, M. P. (2025). Assessing Daylighting Performance and Visual Comfort of Shopping Malls in the Province of Cavite, Philippines. J of Electron Sci and Electrical Res 2(3), 01-21.*

Abstract
In the tropical Philippines, shopping malls serve as cooling centers and cultural hubs, remaining vital even during the COVID-19 pandemic. However, their traditional enclosed designs often limit natural light integration. Retail experts advocate "demalling," which introduces daylight into retail spaces to foster connections between people and nature. While daylighting research is prevalent in offices and schools, shopping malls remain underexplored. This study evaluates daylighting strategies—Clerestory, Floor-to-Ceiling, and Skylight windows—focusing on visual comfort in Cavite's malls. Using surveys, HDR luminance mapping, and simulations, the study links user perceptions to luminance levels.

Results show visual comfort depends more on the interaction of daylight with indoor elements than glare. Effective navigation mitigates occasional glare discomfort. For instance, Imus Mall's clerestory windows achieve optimal illuminance (100–3000 lux), enhancing visual comfort and reducing artificial lighting dependence. Conversely, Bacoor Mall's strategies provide less than 15% useful daylighting, with most areas falling below or exceeding optimal illuminance, highlighting the need for improvement. Recommended thresholds for optimal comfort are clerestory windows below 520 cd/m², skylights under 2250 cd/m², and floor-to-ceiling windows between 1600–5300 cd/m². These values, tailored for dynamic user environments like malls, can guide designs for improved comfort. Integrating these thresholds and using daylighting simulation tools during the design phase can significantly enhance visual satisfaction in Philippine malls.

Keywords: Visual Comfort, Daylighting Design, Luminance Metrics, Sustainability.

Introduction

Background of the Study

In the Philippine Tropical Climate, shopping malls are known to be hotspot to cool off the summer heat and has become a main cultural and social center of Filipinos [1]. There was a shift in consumer behavior during the COVID-19 outbreak that caused the rise of online shopping due to the lockdown measures however, despite this shift, malls have bounced back and has not only become a retail space but also an important pillar into building a community [2]. The average time spent in shopping malls is 2 to 3 hours per visit. Major Mall developers have reported that in 2021 to 2022 pre-COVID levels, the consumer traffic rose from 40% to 85% - 95% [3]. Consumers prefer to buy items in-store because they appreciate the sensory experience, which includes how the product looks, feels, fits, and smells, despite the ease and convenience offered by online shopping [4].

However, the typical shopping malls are characterized by their enclosed architectural design, which creates a barrier inhibiting the interplay between nature and shopping experience [5]. The rigid setup of mall has become merely a context to serve more immediate concerns with fulfilling consumption needs that seemingly deny shoppers meaningful experiences and encourage shopper boredom that entails lack of unique experiences and newness to the mall (Relph, 1976).

Experts in retailing propose that developers and retailers who engage in "demalling" - a concept described can enhance shopper engagement, as highlighted [6-8]. Moreover, Customer satisfaction with the indoor environment directly impacts their loyalty. To ensure continued patronage from shopping mall customers, it is crucial to prioritize both physical and psychological comfort and well-being through design strategies aimed at enhancing satisfaction with the indoor environment [9].

Statement of the Problem

As these shopping malls typically enclosed concrete architectural design and the use of artificial lighting that in regions with abundant natural sunlight, there is a need to design the common spaces of a community mall utilizing daylight that promotes visual comfort. Addressing this research problem is essential to mitigate the significant energy demands associated with artificial lighting in tropical shopping malls while enhancing visual comfort and minimizing environmental impact.

Goals and Objectives

To assess the daylighting performance of shopping malls and its effects on the visual comfort of shopping mall users in Cavite and to propose community mall that utilizes the tropical climate of the Philippines through daylighting strategies that provides visual comfort to users.

Objectives

1. Assess the visual comfort of customers in shopping mall daylight design in the Philippines.
2. Determine the daylighting visual performance of the common space of shopping mall design in the Philippines.

Significance of the Study

Addressing this research problem is essential to mitigate the significant energy demands associated with artificial lighting in tropical shopping malls while enhancing visual comfort to improve indoor health environment of community shopping malls. This study will inform mall developers to and policymakers about the benefits of daylighting in creating more engaging and sustainable retail environments. Moreover, this study aligns with the United Nations Sustainable Development Goals (SDGs), primarily SDG 11: Sustainable Cities and Communities with the use of daylighting of shopping malls. It also addresses SDG 3: Good Health and Wellbeing through enhancing healthier indoor environment and SDG 7: Affordable and Clean Energy by promoting the use of daylighting as natural illumination of spaces.

Scope and Limitations

This study investigates daylighting visual comfort and performance in shopping malls within Metro Manila, specifically in Cavite, to provide a contextual analysis based on local environmental conditions, site characteristics, and community dynamics. It evaluates the adequacy and effectiveness of current daylighting strategies in enhancing customer visual comfort and explores user perceptions and preferences within mall environments. The research also aims to propose improvements for sustainable lighting design tailored to the Philippine context, including the conceptualization of a community mall model. While findings may have limited generalizability beyond Metro Manila due to regional variations in environmental and cultural factors, the study offers valuable insights into optimizing daylighting in mall design. Practical limitations, including time, budget, and regulatory constraints, may affect data collection. Nonetheless, the research contributes to sustainable architectural practices and supports the advancement of the United Nations Sustainable Development Goals.

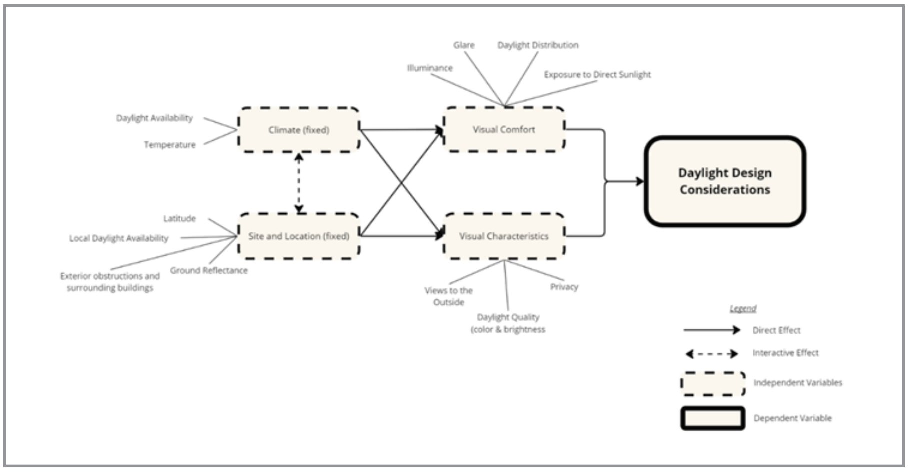


Figure 1: Conceptual Framework

Review of Related Literature

Cultural and Social Significance of Shopping malls in Philippines

Shopping malls in the Philippines play a vital cultural and social role, functioning not only as retail centers but also as community spaces where Filipinos engage in a wide range of activities reports that 80% of Filipinos visit malls monthly, underscoring their integration into daily life [9, 10]. Beyond shopping, malls offer dining, entertainment, recreation, and venues for social gatherings. Their cultural significance is shaped by the country's tropical climate, making air-conditioned malls attractive for comfort, and by the Filipino value of bayanihan, which promotes social interaction and communal unity within these shared spaces.

Daylighting

Daylighting plays a crucial role in shaping indoor environments and influencing occupants' visual comfort and well-being. Research has shown that exposure to natural light positively impacts human health, productivity, and mood [11]. Studies have demonstrated that access to natural light can reduce eyestrain, fatigue, and discomfort, leading to improved satisfaction and performance in indoor environments [12]. Therefore, understanding the relationship between daylighting and visual comfort is essential for designing sustainable and user-friendly built environments.

Visual Comfort of Daylighting

In the context of indoor daylight environments, visual comfort refers to the subjective perception of lighting conditions and their impact on occupants' visual tasks and overall well-being. People experience visual comfort when they have the right amount of light—natural or artificial—to perform their tasks. Research on visual comfort has explored various factors, including illuminance levels, glare, color temperature, exposure to direct sunlight and lighting distribution, to determine their influence on occupants' visual perception and satisfaction [14].

Daylighting Performance Towards Visual Comfort

Since Daylight in buildings is composed of a mix of direct sunlight, diffuse light from skylight, and light reflected from the ground and surrounding elements. The methods to evaluate daylight are:

Luminance-Based Metrics

Luminance, defined as the amount of light reflected or emitted from a surface, is closely linked to human perception of daylight. Studies suggest that luminance-based metrics, especially from the occupant's point of view, correlate more strongly with subjective visual comfort than illuminance-based measures. High Dynamic Range (HDR) imaging enables accurate luminance measurement—within 10% accuracy—by merging multiple exposures from a single viewpoint, producing high-resolution data over a wide field of view [15]. Glare, a key factor in visual discomfort, results from excessive luminance contrast within the visual field.

Furthermore, daylighting research highlights the value of incorporating biophilic design to strengthen occupants' connection to nature, thereby enhancing satisfaction and well-being [16, 17].

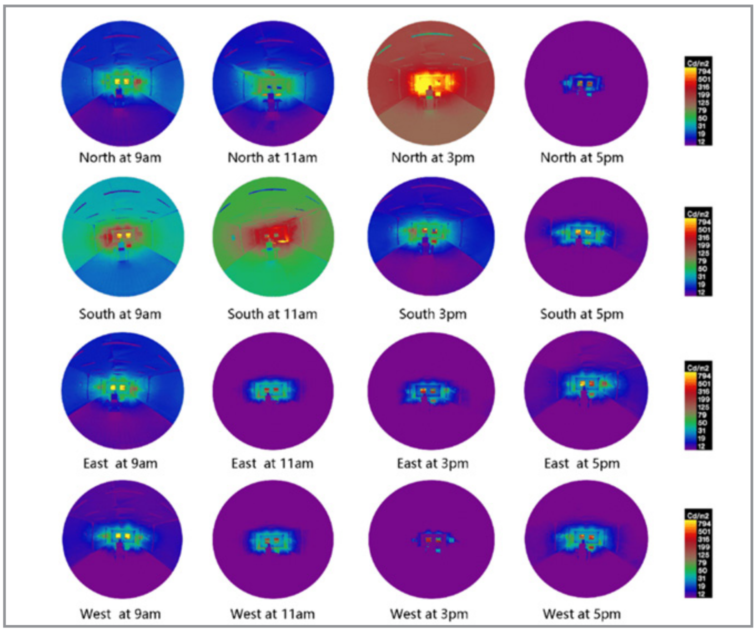


Figure 17: HDR Imaging Luminance Analysis using Aftab Alpha Software

Local Daylighting Standards

Daylighting regulations in the Philippines are primarily guided by the Green Building Code of 2015 and the Philippine Department of Energy Building Guidelines of 2020. These are aligned with international standards, including the IESNA Lighting Handbook and ASHRAE 90.1. For shopping malls, the IESNA categorizes recommended illuminance levels under "Lighting for Working and Activity Interiors," suggesting a range of 300 to 750 lux to ensure adequate visual comfort and functionality.

Review of Related Literature

Table 1: Related Studies Reviewed

Author(s)	Year	Research Area	Building Type	Location of Studies	Type of Analysis
Mayhoub and Rabboh	2022	Influences of Daylighting Perception, Preference, and Satisfaction of Customer's	Shopping mall	Cairo, Egypt	Daylighting Illumination and Customers Perception, Preference, and Satisfaction
Jin, Li, Kang, and Kong	2017	Luminance Metrics	Shopping center	4 cities in China	Mean Illuminance Value
Du, Zhang, and Lv	2020	Indoor Environmental Quality and Customer's Perception	Shopping mall	Beijing, China	Customer Perception, and IEQ Parameters and Standards
Hourani and Hammod	2012	Dynamic Daylighting Quality	City Mall	Amman, Jordan	Illuminance Metrics
Liu B., Liu Y., Deng, and Hu	2023	Daylighting and Visual Comfort	Primary School	Guangzhou, China	Illuminance Measurements

The reviewed studies employed diverse methodologies, including field surveys, questionnaires, field measurements, photographic observations, and simulation analyses. Findings highlight the importance of illumination levels, daylight quality, and indoor environmental quality (IEQ) parameters in shaping customer perceptions, satisfaction, and visual comfort in shopping malls and similar settings. Key metrics such as mean luminance, illuminance, and IEQ indicators were assessed to evaluate their influence on occupant experience. However, gaps remain in the literature—particularly a lack of research focused on Philippine shopping malls. There is a need for more integrated studies combining both subjective user feedback and objective lighting data to better understand the impact of daylighting on visual comfort in this specific context.

Theoretical Framework

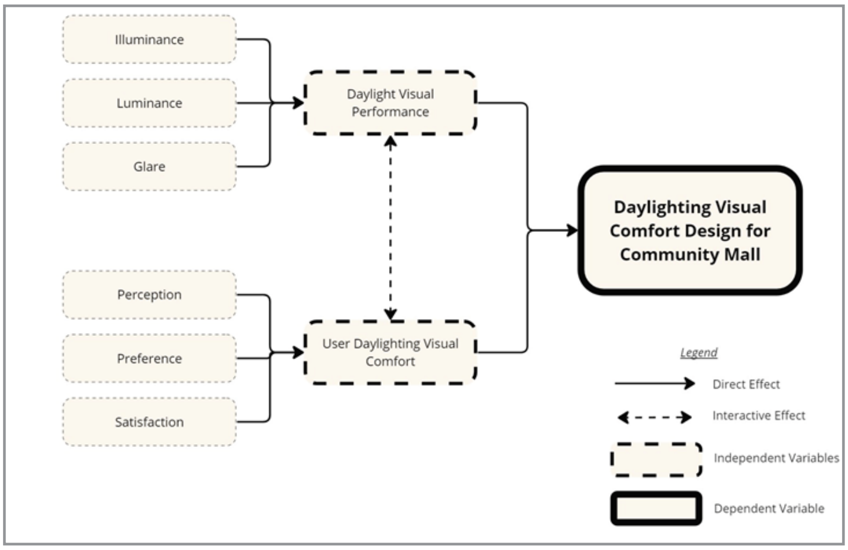


Figure 24: Theoretical Framework

The Theoretical Framework combines subjective and objective measures of daylighting to assess the daylighting performance and visual comfort of community shopping malls in the Philippines to enhance the indoor health environment through visual comfort in community shopping malls.

Methodology

Research Design

The study employs a mixed-methods research design, combining qualitative and quantitative approaches to assess daylighting visual comfort and performance in Philippine shopping malls. Qualitatively, a questionnaire captures customer perceptions, preferences, and satisfaction with daylighting. Quantitatively, daylighting measurements—using a digital lux meter, cameras, and Aftab Alpha software—provide objective data on illuminance, luminance, and glare within mall environments.

Instruments and Materials

This study employed both subjective and objective methods to evaluate daylighting visual comfort in conventional Philippine shopping malls. A structured questionnaire served as the primary instrument for assessing users' perceptions, preferences, and satisfaction with daylighting conditions. Administered to a targeted sample population, the survey collected data on key comfort indicators, which were then statistically analyzed to determine the relationship between daylight quality and perceived visual comfort.

Complementing the survey, daylighting performance was assessed through field measurements and simulation modeling. Illuminance levels were recorded using a digital lux meter, while luminance and glare were captured via HDR imaging and analyzed with Aftab Alpha software. The collected data were compared against established lighting standards to evaluate the adequacy of current daylighting strategies [18-21]. This integrated methodology provided a comprehensive understanding of visual comfort and informed design recommendations for improving daylighting performance in shopping mall environments.

Data Analysis

Spearman's rank correlation was used to analyze monotonic relationships between daylighting variables and visual comfort, suitable for the ordinal 5-point Likert scale data without assuming normality. Differences in visual comfort across demographic groups and daylighting strategies were examined using Kruskal-Wallis and Mann-Whitney U tests, appropriate for non-normally distributed data.

Ordinal Logistic Regression identified optimal luminance levels for each daylighting strategy, modeling satisfaction ratings based on measured luminance. Together, these methods provided a comprehensive assessment of daylight quality's impact on visual comfort, supporting recommendations for enhancing user experience in shopping malls [22-26].

Methodological Framework

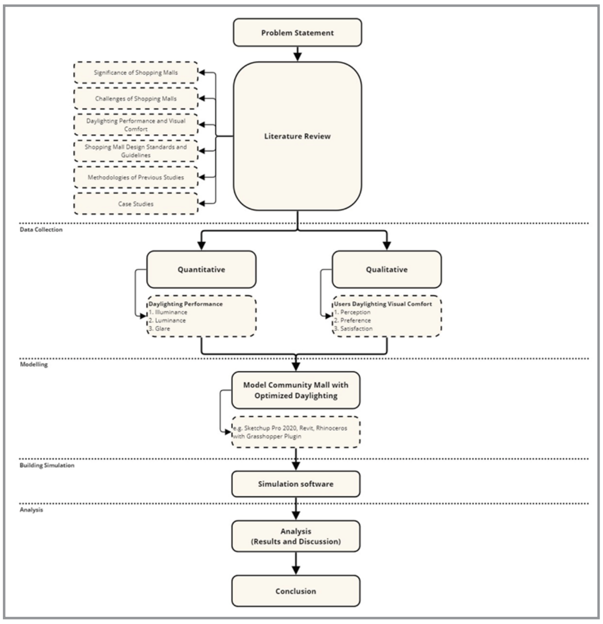


Figure 25: Methodological Framework

This part of the study shows the methodological framework to assess the daylighting performance and visual comfort of community shopping malls in the Province of Cavite and propose a community mall that optimizes Daylighting Visual Comfort [27].

Results and Discussion

Figure 26. shows the Input-Process-Output of the Analysis. Variables for Input are the measured luminance from the HDR luminance capture and user visual comfort survey responses. The Processing of raw data uses the data analysis techniques discussed in the methodology. Lastly the Output of the whole research will show the resulted Visual Comfort Luminance Levels for each daylighting strategy and the daylighting availability simulation results of each shopping mall. This chapter of the study will discuss starting from the Process and Output of the Analytical Framework.

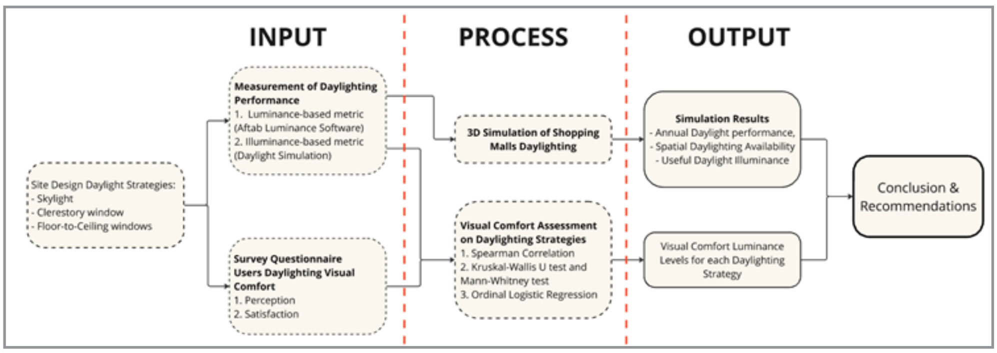


Figure 26: Analytical Framework

Data Gathering

The researcher collected 305 questionnaire responses on-site and captured four HDR scenes per daylighting strategy each day (Appendix D). The questionnaire covered (1) visual comfort and illuminance indicators—glare, contrast, distraction, and clarity, (2) thermal conditions, (3) mall usage, and (4) user characteristics. Data collection occurred over four days—June 3, 5, 6, and 7, 2024—from 11:30 a.m. to 6:00 p.m. Although daylight varied, weather conditions remained consistently overcast from 12:00 p.m. to 6:00 p.m. Minimizing variability and ensuring consistency in visual comfort evaluation [28, 29].

User Visual Comfort Survey Questionnaire

The visual comfort survey utilized a 5-point Likert scale, adapted from established studies on daylighting visual comfort and modified for shopping mall contexts [18]. The survey comprised three main sections: (1) Perception towards Daylighting, (2) Visual Comfort Satisfaction, and (3) Overall Satisfaction with the Daylighting Strategy, as outlined in Table 3. Additional demographic and behavioral questions—including age, gender, income, time spent in the mall, visitation frequency, and primary activities—are presented in Appendix A [30, 31].

To assess user visual comfort, the survey captured responses on daylighting familiarity, perceived brightness, and perceived importance. Visual comfort indicators included thermal sensation, glare, visual distraction, and clarity. Respondents also rated their overall satisfaction with the daylighting strategy and their likelihood of revisiting malls with similar daylighting features (Appendix A).

Results

Correlation with Visual Comfort and Illumination Assessments

A correlation between visual comfort and illumination assessments was conducted to see its relationship to the measured luminance values and overall visual satisfaction and visit likelihood responses.

Measured Luminance

As the questionnaire survey used 'Point-in-time' sampling, time periods were used to integrate quantitative generated luminance from the HDR imaging to the qualitative assessment questionnaire data. The point-in-time measured luminance data are shown in Appendix C. Table 5 shows the relationship between the measured luminance from the HDR imaging and visual comfort assessment [32].

The HDR Image for each scene generated luminance value for minimum Luminance (Lmin), maximum Luminance (Lmax), mean Luminance (Lmean), and median Luminance (Lmedian). It was found that the measured daylighting performance correlates to all questions except for Q1. Know daylight (Familiarity with Daylighting in a space). However, the rest of the visual comfort questions are significantly correlated with the measured luminance.

Table 5: Correlation between Objective Measured Luminance and Subjective Visual Comfort Evaluation

Spearman Rho		Measured Luminance			
		Lmin	Lmax	Lmean	Lmedian
Q1. knowdaylight	Correlation Coefficient	-0.068	-0.094	-0.018	-0.081
	Sig. (2-tailed)	0.235	0.102	0.758	0.157
Q2. brightness	Correlation Coefficient	0.457**	0.439**	0.406**	0.512**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001
Q3. tempsense	Correlation Coefficient	-0.323**	-0.175**	-0.322**	-0.227**
	Sig. (2-tailed)	<.001	0.002	<.001	<.001
Q4. importance	Correlation Coefficient	-0.223**	-0.178**	-0.24**	-0.157**
	Sig. (2-tailed)	<.001	0.002	<.001	0.006
Q5. glaresense	Correlation Coefficient	-0.53**	-0.354**	-0.654**	-0.403**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001
Q6. visualdistract	Correlation Coefficient	-0.418**	-0.236**	-0.559**	-0.278**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001
Q7. visualclarity	Correlation Coefficient	-0.329**	-0.174**	-0.434**	-0.206**
	Sig. (2-tailed)	<.001	0.002	<.001	<.001
Q8. ovsatisfaction	Correlation Coefficient	-0.244**	-0.095	-0.339**	-0.131*
	Sig. (2-tailed)	<.001	0.096	<.001	0.022

Q9. visitlikelihood	Correlation Coefficient	-0.218**	-0.089	-0.325**	-0.084
	Sig. (2-tailed)	<.001	0.120	<.001	0.142

Note: **. Correlation is significant at the 0.01 level(2-tailed), *. Correlation is significant at the 0.05 level(2-tailed)

Differences in Daylighting Strategy

A total of 305 respondents were collected from two (2) shopping malls in the province of Cavite shown in Table 10. The number of respondents for each daylighting strategy is shown in Table 11.

A difference analysis was used to see whether there would be significant differences in visual comfort assessment between the three (3) daylighting strategies used in the shopping mall.

Table 10: Descriptive Statistics of Location and Daylighting Strategies

	N	Min.	Max.	Mean	Std. Deviation
Location	305	1	2	1.50	0.501
Daylight Strategies	305	1	3	1.62	0.798

Table 11: Number of Respondents for Each Daylighting Strategy

Daylighting Strategies	No. of Respondents
Clerestory *CLE	176 (57.5%)
Floor-to-Ceiling *FTC	68 (22.2%)
Skylight 9 *SKY	61 (19.9%)
Total	305 (100.0)

Table 12 shows that there is significant difference between the three daylighting strategies in answering the questions for brightness, temperature sensation, importance of daylighting, glare sensation, visual distraction, visual clarity, overall satisfaction, and visit likelihood. To further assess differences between daylighting strategies, the Mann-Whitney test was used to find the significant difference between two independent variables, in this case two daylighting strategies [35-38].

Table 12: Kruskal-Wallis Test on Daylighting Strategies Towards Visual Comfort Questionnaire

Kruskal-Wallis test		
Group by Daylight Strategies	**Kruskal-Wallis H**	**Asymptotic Significance**
Q1. knowdaylight	0.072	0.964
Q2. brightness	95.409	<0.001
Q3. tempsense	48.256	<0.001
Q4. importance	13.242	<0.001
Q5. glaresense	161.913	<0.001
Q6. visualdistract	130.327	<0.001
Q7. visualclarity	89.407	<0.001
Q8. ovsatisfaction	60.734	<0.001
Q9. visitlikelihood	72.411	<0.001

Note: *p< 0.05 – significant difference

Significant differences were observed in visual comfort ratings among the three daylighting strategies. Between clerestory and floor-to-ceiling windows, all survey items differed significantly except for daylighting familiarity (Q1) and perceived brightness (Q2). For skylights versus floor-to-ceiling windows, differences emerged in brightness, visual distraction, clarity, overall satisfaction, and visit likelihood. Between clerestory and skylights, all items showed significant differences except for Q1. These results, along with correlations between daylighting strategies, visual comfort assessments, and measured performance, informed the identification of luminance levels that enhance overall visual satisfaction [40].

Luminance Level That Affects Overall Visual Comfort Satisfaction

In this analysis, a regression analysis between the visual comfort assessment and Lmean is conducted where in an Estimated Responses Probability (EST) is generated. This EST is graphed per response category by Lmean to find at what Luminance levels have the highest likelihood of positive visual comfort evaluation.

Regression of Visual Comfort Satisfaction Questions and Overall Visual Comfort Satisfaction

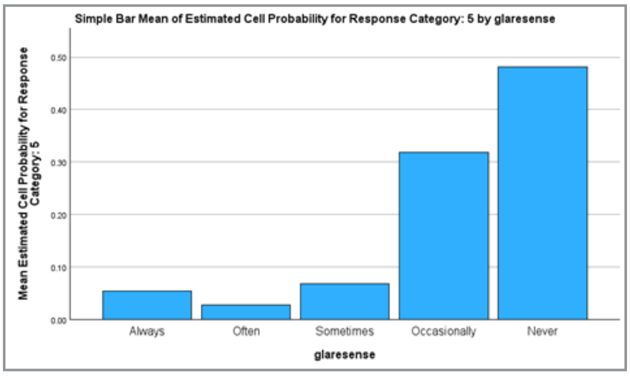
Table 14 shows the visual comfort locations in the ordinal regression that have significant ($p<0.05$) predictors of overall visual satisfaction. Estimated responses probability was generated and graphed to see which answers from the visual comfort predictors would have a higher likelihood of a 5-Very Satisfied overall visual satisfaction.

Figure 31 shows that the higher rating (5) of glare sensation, visual distraction, and visual clarity experienced the higher the likelihood of overall visual satisfaction (5 – Very Satisfied).

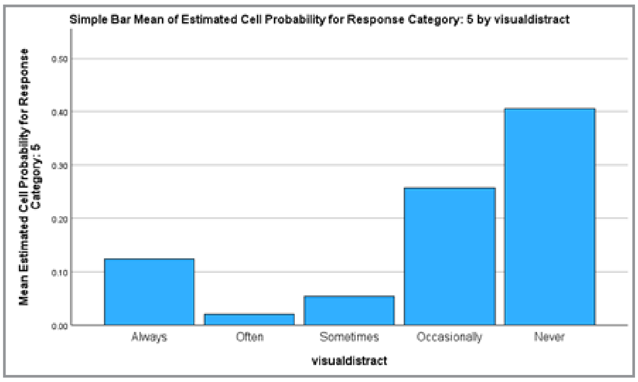
Table 14: Ordinal Logistic Regression for Overall Visual Satisfaction based on Visual Comfort Factors

Parameter Estimates		Estimate	Sig.
Threshold	[S1_satisfaction = 1]	-27.929	0.989
	[S1_satisfaction = 2]	-10.197	<.001
	[S1_satisfaction = 3]	-6.758	<.001
	[S1_satisfaction = 4]	-2.568	0.028
Location	[VC1_glaresense=1]	-1.195	0.202
	[VC1_glaresense=2]	-2.107	0.002*
	[VC1_glaresense=3]	-2.144	<.001*
	[VC1_glaresense=4]	-0.933	0.022*
	[VC1_glaresense=5]	0	.
	[VC2_visualdistract=1]	-3.144	0.203
	[VC2_visualdistract=2]	-1.729	0.007*
	[VC2_visualdistract=3]	-1.396	0.014*
	[VC2_visualdistract=4]	-0.04	0.92
	[VC2_visualdistract=5]	0	.
	[VC3_visualclarity=1]	-2.68	0.121
	[VC3_visualclarity=2]	-3.473	<.001*
	[VC3_visualclarity=3]	-2.188	<.001*
	[VC3_visualclarity=4]	-1.207	0.002*
	[VC3_visualclarity=5]	0	.

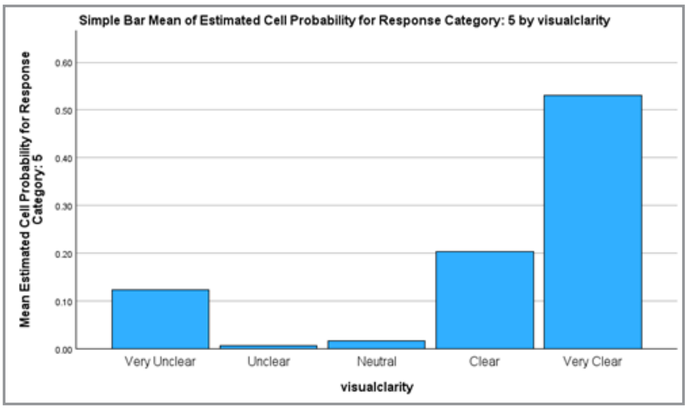
Note: *$p< 0.05$ – significant predictor



(a) Glare Sensation (1- Always, 2 - Often, 3- Sometimes, 4 – Occasionally, 5 – Never)



(b) Visual Distraction (1- Always, 2 - Often, 3- Sometimes, 4 – Occasionally, 5 – Never)



(c) Visual Clarity (1 – Very Unclear, 2 – Unclear, 3 – Neutral, 4 – Clear, 5 – Very Clear)

Figure 31: Estimated Response Probability for category 5 (Very Satisfied) of Overall Visual Satisfaction

Luminance Level for Clerestory

The highest are peak for response 5 is for glare sensation is ~130.33 cd/m2 while for visual distraction is ~243.23 cd/m2. Looking into Figure 33, between the ranges ~179.89 cd/m2 to ~519.43 cd/m2 show high likelihood of responding to category 4 for the visual comfort assessment.

It can be concluded that the likelihood of the response to be 4-Satisfied or 5-Very Satisfied is less than 520 cd/m2 Luminance Level for Clerestory windows shown in Figure 34.

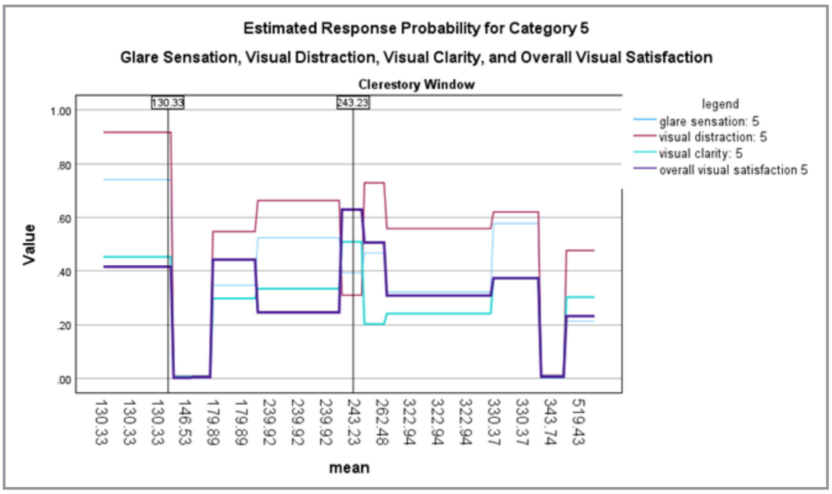


Figure 32: Estimated Response Probability for Category 5 of Glare Sensation, Visual Distraction, Visual Clarity, and Overall Visual Satisfaction by mean Luminance

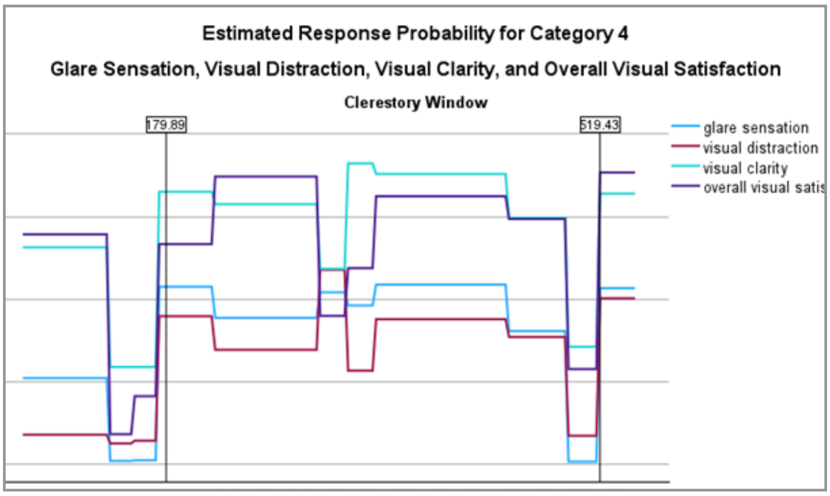


Figure 33: Estimated Response Probability for Category 4 of Glare Sensation, Visual Distraction, Visual Clarity, and Overall Visual Satisfaction by Mean Luminance

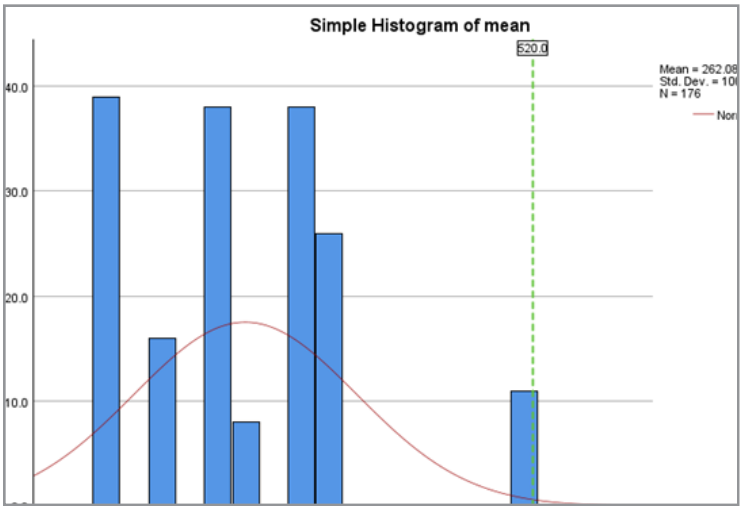


Figure 34: Luminance Visual Comfort Level for Clerestory Window

Luminance Level for Skylight
The same analysis was done for Skylights, and it is shown in Figure 37, the concluded luminance level is less than 2250 cd/m2 for overall visual satisfaction.

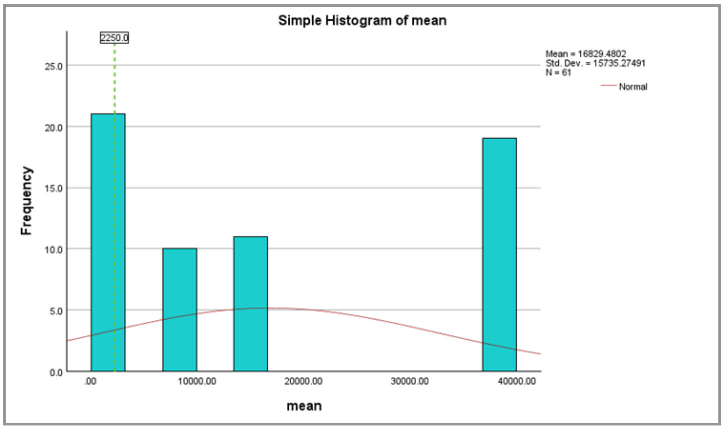


Figure 37: Luminance Visual Comfort Level for Skylight

Luminance Level for Floor-to-Ceiling Window
Figure 42 shows graphs that the luminance values which have the highest likelihood of the response to be in Categories 4 or 5 are between the ranges 1600 cd/m2 to 5300 cd/m2. Although the lower rangers were deemed to cause negative responses, Category 2 and 3, shown in Figure 40 and Figure 41, the data for the lower luminance levels then needs to be validated for future studies of floor-to-ceiling windows in shopping malls [42, 43].

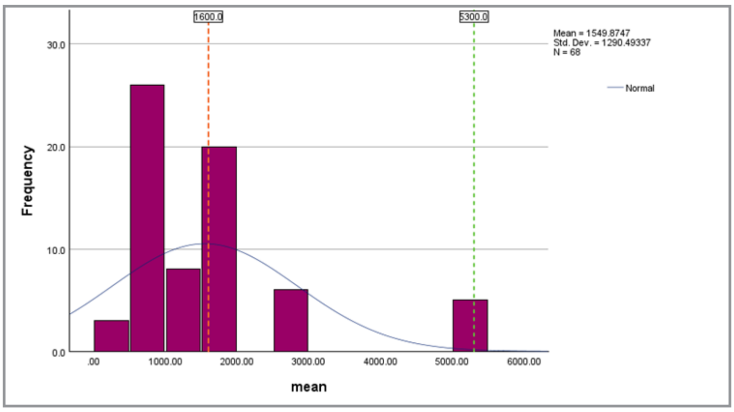


Figure 42: Luminance Visual Comfort Level for Floor to Ceiling Window

The researcher's findings indicate that for shopping mall users, the primary factor influencing visual comfort and satisfaction is not the sensation of glare itself, but rather how daylight interacts with indoor elements. This contrasts with other studies that focus on respondents engaged in specific tasks within designated areas to assess visual comfort. Unlike these task-oriented environments, shopping mall users are typically mobile and not confined to a specific location. While they may encounter glare sensations within the mall, their ability to move freely allows them to seek areas with less glare, thereby mitigating discomfort. Consequently, the interaction between daylight and the mall's interior architecture plays a crucial role in shaping the overall visual comfort and satisfaction of the users [44].

Conclusion and Recommendations

Daylighting plays a vital role in shaping indoor environments, directly influencing occupants' visual comfort and well-being. As shopping malls remain central to social and cultural life in the Philippines, there is a growing need for human-centric, sustainable design approaches that prioritize visual comfort. The study found that visual comfort in shopping malls is primarily influenced by how daylight interacts with interior elements, rather than the sensation of glare itself. Unlike task-oriented settings such as offices or classrooms, mall users are mobile and not confined to a fixed field of view, allowing them to avoid glare by moving to more comfortable areas. As such, traditional glare assessments may not be applicable in mall settings. Instead, glare simulations or general glare experience surveys are recommended [45, 46].

While visual comfort showed a slight positive influence on users' likelihood to visit, it is only one of several contributing factors. Despite some negative perceptions of visual comfort, most users still reported a high likelihood of revisiting the mall, suggesting that other elements—such as store variety, architectural design, thermal and acoustic comfort—also play significant roles. It is recommended that future studies assess additional indoor environmental factors and retail mix to better understand what drives visitation. The study also identified luminance thresholds for optimal visual satisfaction: below 520 cd/m² for clerestory windows, below 2250 cd/m² for skylights, and between 1600–5300 cd/m² for floor-to-ceiling windows. Although some neutral responses overlapped with these values, they are considered outliers or affected by external variables [47]. These thresholds, derived from roaming user assessments, may not be generalizable to building types with static users. Further validation is needed, but these findings can inform daylighting simulations during the design phase, using BIM tools to calibrate luminance and reduce visual discomfort in operational malls [48].

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Appendix

Appendix A: Visual Comfort Survey Questionnaire

To be filled out by Researcher

Date:

Time:

Location: (Bacoor Mall/Imus Mall)

Daylighting Strategy: (Clerestory/Floor-to-Ceiling/Skylight)

Personal Behavior

1. Gaano katagal kayo nakatambay sa loob ng mall? Time Spent in the Shopping Mall?

[ ] <1 hour

[ ] 1 hour to 2 hours

[ ] 2 hours to 3 hours

[ ] 3 to 4 hours

[ ] >4 hours

2. Gaano kadalas ka pumunta sa Mall na ito? How often do you go to this mall?

[ ] Bihira lamang (Rarely)

[ ] Paminsan lamang (Seldom)

[ ] Isang beses sa isang buwan (Once a month)
[ ] Isang beses sa isang linggo (Once a week)
[ ] Higit sa isang beses sa isang linggo(More than Once a week)
3. Ano ang mga karaniwang ginagawa mo sa Mall? What is your Main Activity in the shopping mall? *Check all that apply
[ ] Shopping (retail/grocery)
[ ] Dining
[ ] Entertainment(cinema)
[ ] Socializing(Meeting place) /Idle (Tambayan)
[ ] Exercise/Health
[ ] Service (Government, bank,etc)

Daylighting Perception
1. Alam mo ba and Daylighting sa isang space? Do you recognize the daylighting in space?
[ ] Very Unfamiliar
[ ] Unfamiliar
[ ] Somewhat Familiar
[ ] Familiar
[ ] Very Familiar
2. Sa tingin mo gaano ka liwanag ang loob ng mall ngayon? How would you classify the mall's brightness now? (regardless of any weather condition)
[ ] Sobrang Madilim (Very Dark)
[ ] Madilim (Dark)
[ ] Moderate
[ ] Maliwanag (Bright)
[ ] Sobrang Maliwanag (Very Bright)
3. Sa tingin mo ba importante ang daylighting sa loob ng mall? Do you think daylighting inside shopping malls is important?
[ ] Hindi Sang-ayon (Strongly Disagree)
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Sang-ayon (Strongly Agree)

Visual Comfort Perception
1. Ano ang pakiramdam mo sa temperature sa loob ng mall? How do you feel about the temperature in space right now?
[ ] Hindi Comportable (Very Uncomforatble)
[ ] Uncomfortable
[ ] Neutral
[ ] Comfortable
[ ] Sobrang Comportable (Very Comfortable)

2. Nakakaramdam ka ba ng nakakasilaw na sinag ng araw na pumapasok sa mall? Do you experience glare sensation?
* Glare sensation - a visual sensation caused by excessive brightness and light in your visual field that your eyes cannot manage correctly
[ ] Hindi (Never)
[ ] Occasionally
[ ] Sometimes
[ ] Often
[ ] Madalas (Always)

3. Nakakaranas ka ba ng Paggambala sa mga kulay o gamit sa loob ng mall dahil sa Sinag ng Araw? Does daylighting make you visually distracted with the colors and objects inside the mall?
[ ] Hindi Nangangambala(Never)
[ ] Occassionally
[ ] Sometimes
[ ] Often
[ ] Madalas Nagngangambala (Always)
4. Nakikita mo ba ng malinaw ang mga gamit o letra dahil sa Sinag ng araw? Do you see the objects or texts inside the shopping mall clearly due to daylighting?
[ ] Hindi malinaw (Very Unclear)
[ ] Unclear
[ ] Neutral
[ ] Clear
[ ] Malinaw (Very Clear)

Overall Visual Satisfaction Towards Daylighting Strategy
1. Nasiyahan ka ba sa kondisyon ng Sinag ng Araw sa loob ng espasyo dahil sa daylighting strategy? How would you rate your overall satisfaction with the daylighting condition of the space because of the daylighting strategy?
[ ] Very Unsatisfied
[ ] Unsatisfied
[ ] Neutral
[ ] Satisfied
[ ] Very Satisfied
2. Babalik ka ba sa isang mall kung gumagamit sila ng ganitong uri ng daylighting strategy? How likely would you visit a mall if they used this kind of daylighting strategy?
[ ] Hindi babalik (Never)
[ ] Occasionally
[ ] Sometimes
[ ] Often
[ ] Madalas babalik (Always)

Demographic
1. Age
[ ] 18-19
[ ] 20s
[ ] 30s
[ ] 40s
[ ] 50s
[ ] 60s
2. Gender
[ ] Male
[ ] Female
3. Income
[ ] At least ₱182,000 and up
[ ] Between ₱109,200 to ₱182,000
[ ] Between ₱63,700 to ₱109,20
[ ] Between ₱36,400 to ₱63,700
[ ] Between ₱18,200 to ₱36,400
[ ] Between ₱9,100 to ₱18,200
[ ] Less than ₱9,100

Appendix B: On-Site Luminance Data Sheets
Location: Imus Mall Sheet
Date: ______________________

Daylighting Type	Time of Day	Illuminance Level (Lux Meter – 3 inches above surface) LUX unit		Temperature (Lux Meter – 0.90m) Celsius	Luminance Record Checker (Camera – Eye Level)
		1	2		
Daylighting/Mixed	11:30am				
Daylighting/Mixed	1:30 pm				
Daylighting/Mixed	3:30 pm				
Daylighting/Mixed	5:30 pm				

Location: Bacoor Mall Sheet
Date: ______________________

Daylighting Strategy	Daylighting Type	Time of Day	Illuminance Level (Lux Meter – 0.90m) LUX unit		Temperature (Lux Meter – 0.90m) Celsius	Luminance Record (Camera – Eye Level)
			1	2		
Skylight	Daylighting/ Mixed	11:30am				
Floor-to-Ceiling	Daylighting/ Mixed	11:30am				
Clerestory	Daylighting/ Mixed	11:30am				
Skylight	Daylighting/ Mixed	1:30 pm				
Floor-to-Ceiling	Daylighting/ Mixed	1:30 pm				
Clerestory	Daylighting/ Mixed	1:30 pm				
Skylight	Daylighting/ Mixed	3:30 pm				
Floor-to-Ceiling	Daylighting/ Mixed	3:30 pm				
Clerestory	Daylighting/ Mixed	3:30 pm				
Skylight	Daylighting/ Mixed	5:30 pm				
Floor-to-Ceiling	Daylighting/ Mixed	5:30 pm				
Clerestory	Daylighting/ Mixed	5:30 pm				

Appendix C: Measured Daylighting Environment Conditions
Imus Mall – Luminance Conditions

IMUS MALL - MEASURED DAYLIGHTING PERFORMANCE									
06/03/2024	GENERATED LUMINANCE METRICS								
LOCATION	TIME	TEMP.	MIN	MAX	MEAN	MEDIAN	DGP	UGR	DGI
11:30									
Q1	11:33	32.4	4.79	1593.16	243.23	242.43	86.13%	59.88	30.29
13:30									
Q2	13:31	29	4.15	4877.75	330.37	238.22	23.89%	20.47	15.39
15:30									
Q3	15:36	29.1	14.99	1430.66	239.92	252.57	23.51%	21.79	17.49
17:30									
Q4	17:32	27.4	1.46	2864	130.33	103.63	6.70%	-4.81	-6.26

06/06/2024	GENERATED LUMINANCE METRICS								
LOCATION	TIME	TEMP.	MIN	MAX	MEAN	MEDIAN	DGP	UGR	DGI
11:30									
Q1	11:30	30.4	5.70	1596.12	262.48	265.16	100%	66.49	32.68
13:30									
Q2	13:30	28.1	6.56	8052.09	519.43	348.15	24.42%	20.85	15.16
15:30									
Q3	15:31	27.2	4.19	5616.12	322.94	222.11	23.01%	20.89	16.86
17:30	lights on								
Q4	17:32	27.5	3.03	3812.81	179.89	158.7	7.50%	1.07	-0.13

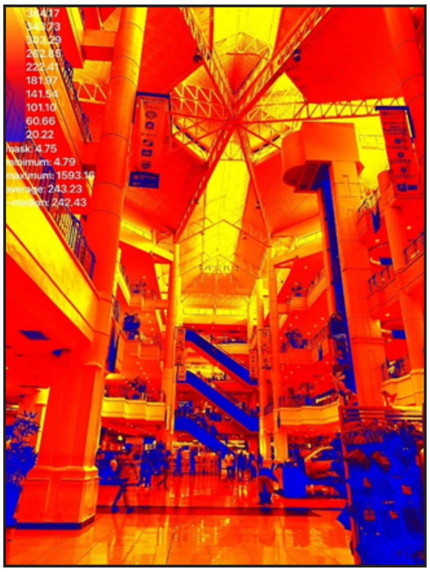
Bacoor Mall – Luminance Conditions

BACOOR MALL - MEASURED DAYLIGHTING PERFORMANCE									
06/05/2024	GENERATED LUMINANCE METRICS								
DAYLIGHTSTRAT	TIME	TEMP.	MIN	MAX	MEAN	MEDIAN	DGP	UGR	DGI
11:30									
skylight	11:31	30.5	50.5	3203.99	907.6	785.84	33.65%	28.75	22.67
	11:31	30.4							
Floor to Ceiling	11:34	29.7	22.44	7357.79	1772.69	545.92	31.00%	32	25.2
	11:34	29.6							
clerestory	11:36	29.5	18.04	8275.84	1138.75	837.75	27.99%	23.72	19.25
	11:36	29.6							
1:30									
skylight	13:31	27.1	128	9323.21	1540.74	593.4	32.08%	27.14	21.1
	13:31	27							
Floor to Ceiling	13:33	25.9	7.99	3302.33	562.13	217.5	29.50%	32.4	25.2
	13:33	25.8							
clerestory	13:35	25.8	1.71	1238.85	146.61	108.07	30.65%	26.87	21.89
	13:35	25.8							
3:30	lights on								
skylight	15:30	26.5	54.12	27329.72	2247.77	1017.48	25.91%	25.33	19.69
	15:30	26.6							
Floor to Ceiling	15:32	26.9	6.89	3175.8	529.6	194.01	27.10%	28.3	22.6
	15:32	26.9							
clerestory	15:36	26.8	2.31	694.18	146.53	162.82	34.27%	31.79	25.6
	15:36	26.4							
5:30	lights on								
skylight	17:30	26.5	33.97	25920.99	2099.02	868.09	16.59%	0	0
	17:30	26.3							
curtain wall	17:32	26.1	6.96	2284.71	455.31	172.85	10.90%	0	0
	17:32	26.1							
clerestory	17:34	26.2	4.1	2430.99	343.74	273	24.96%	23.69	19.92
	17:34	26.2							

06/07/2024	GENERATED LUMINANCE METRICS								
DAYLIGHTSTRAT	TIME	TEMP.	MIN	MAX	MEAN	MEDIAN	DGP	UGR	DGI
11:30									
skylight	11:30	30.9	262.7	28969.36	9166.97	8171.35	35.63%	29.42	23.13
	11:30	30.9							
curtain wall	11:33	29.9	70.74	20397.05	5257.82	2378.01	31.90%	33.3	26
	11:33	29.8							
clerestory	11:36	29.1	29.28	18849.6	2696.97	2310.05	28.77%	24.04	19.5
	11:36	29							
13:30									
skylight	13:31	26.3	493.48	184377.2	39022.54	17286.93	30.30%	25.95	20.28
	13:31	26.3							
curtain wall	13:34	26.6	39.59	12143.81	2970.97	1248.27	30%	33	25.5
	13:34	26.6							
clerestory	13:36	26.4	42.98	26841.05	3920.87	3032.82	30.21%	26.16	21.29
	13:36	26.5							
15:30									
skylight	15:35	26.3	211.06	89451.67	14394.42	5052.5	25.97%	25.39	19.75
	15:35	26.2							
curtain wall	15:32	26.7	22.55	7844.9	1665.84	607.87	27.10%	28.3	22.7
	15:32	26.7							
clerestory	15:29	26.7	6.06	3618.93	513.82	468.43	34.26%	31.67	25.58
	15:29	26.7							
17:30	lights on								
skylight	17:30	25.4	43.56	40873.75	3323.92	1012.13	17.61%	-11.11	-12.94
	17:30	25.3							
curtain wall	17:32	26.6	16.23	8013.83	1312.07	457.04	15.60%	0	0
	17:32	25.6							
clerestory	17:34	25.9	6.22	10397.89	828.47	651	27.30%	27.72	22.6
	17:34	25.9							

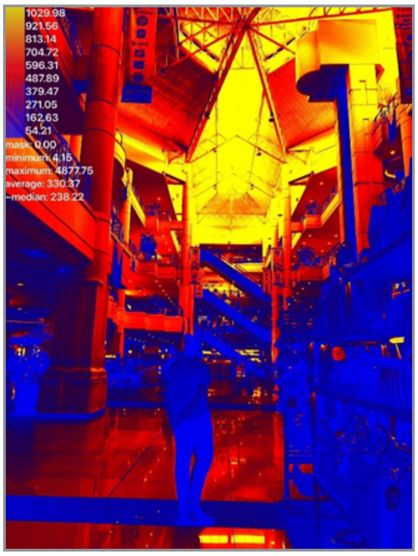
Appendix D: HDR Luminance Maps

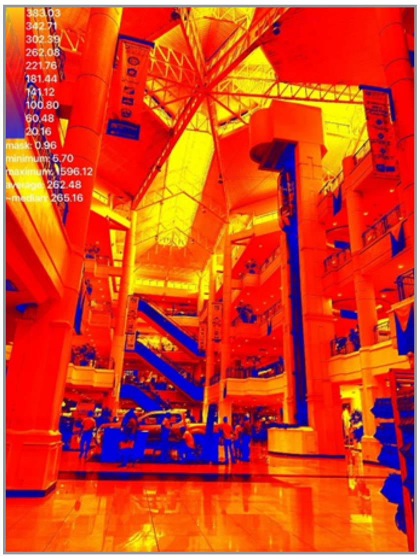
Imus Mall – June 3, 2024, at 11:30 am



Imus Mall – June 3, 2024, at 1:30 pm

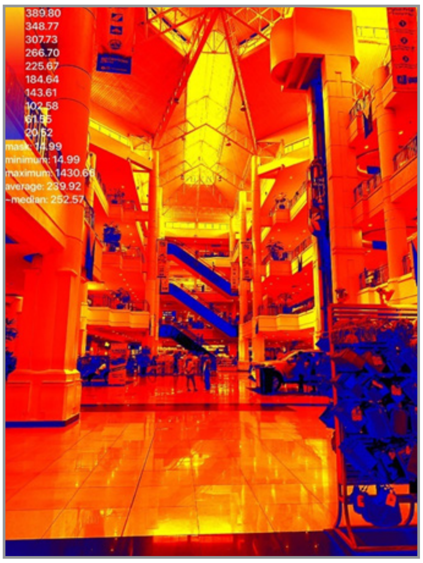
Imus Mall – June 6, 2024, at 11:30 am

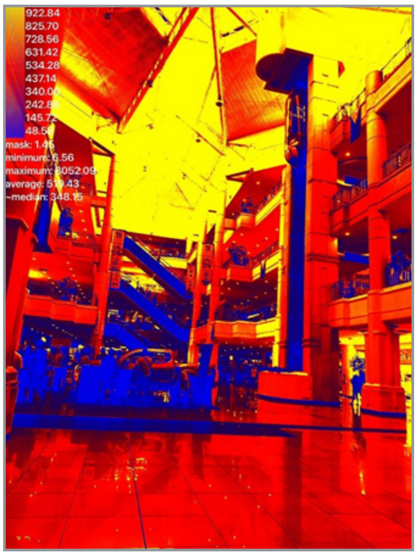




Imus Mall – June 3, 2024, at 3:30 pm

Imus Mall – June 6, 2024, at 1:30 pm

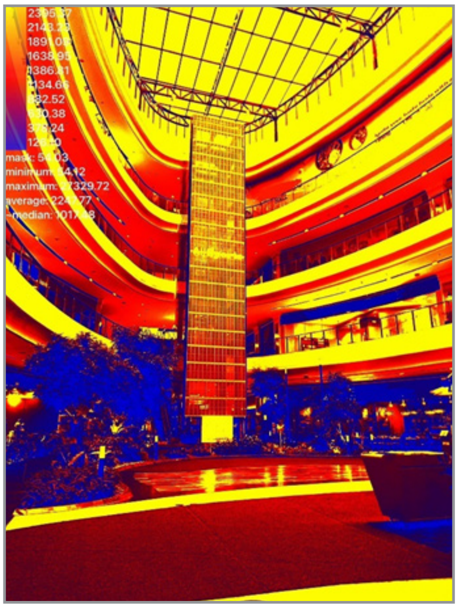




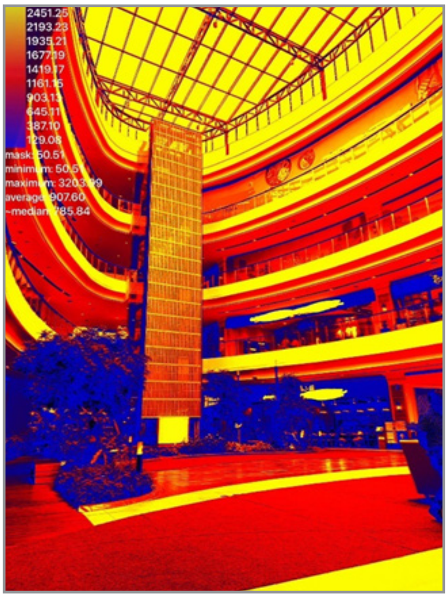
Imus Mall – June 3, 2024, at 5:30 pm

Imus Mall – June 6, 2024, at 5:30 pm

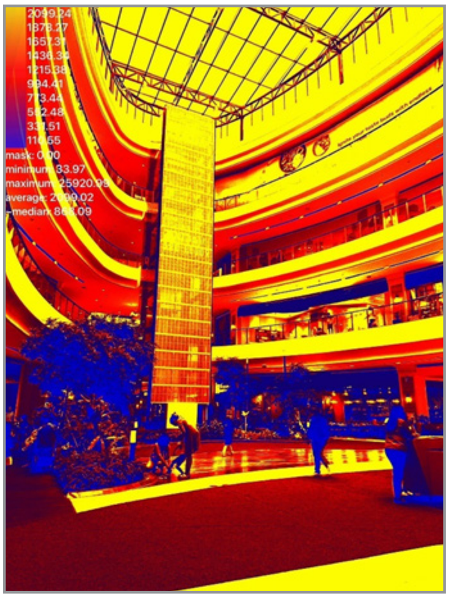
Bacoor Mall Skylight – June 5, 2024



(c) 3:30 pm

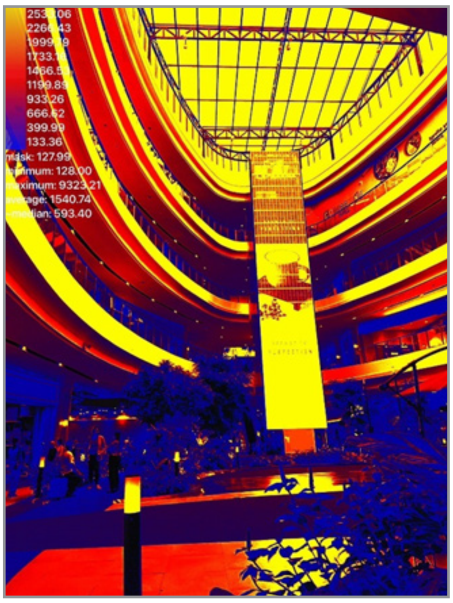


(a) 11:30 am

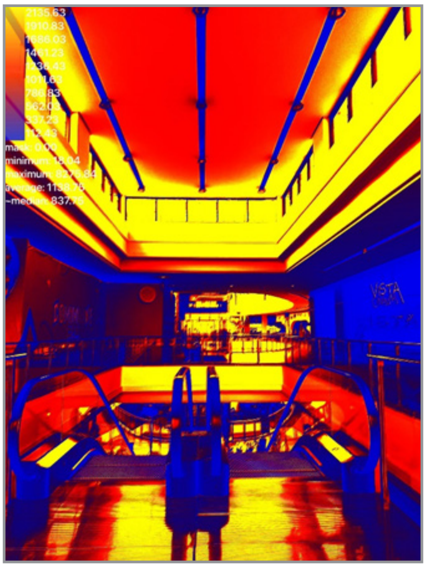


(d) 5:30 pm

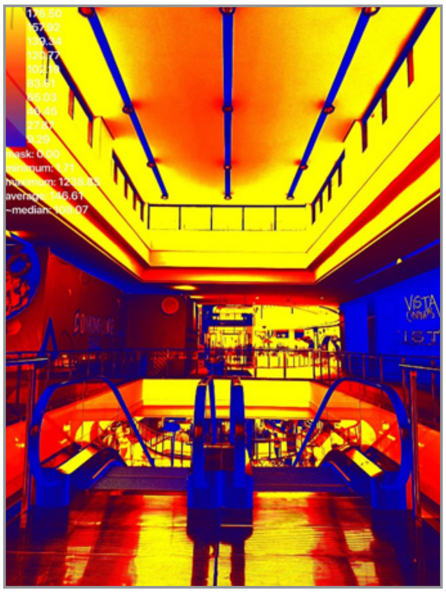
Bacoor Mall Clerestory – June 5, 2024



(b) 1:30 pm



(a) 11:30 am



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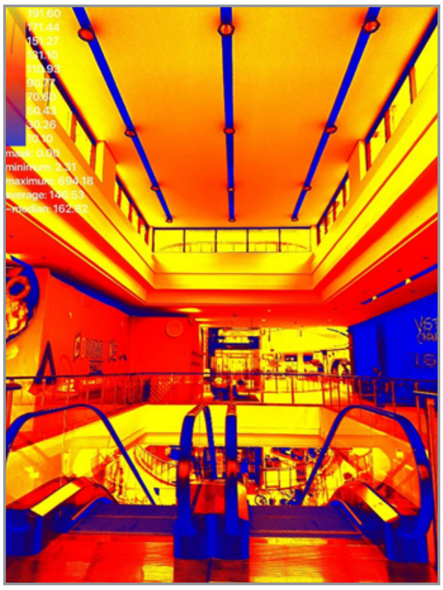
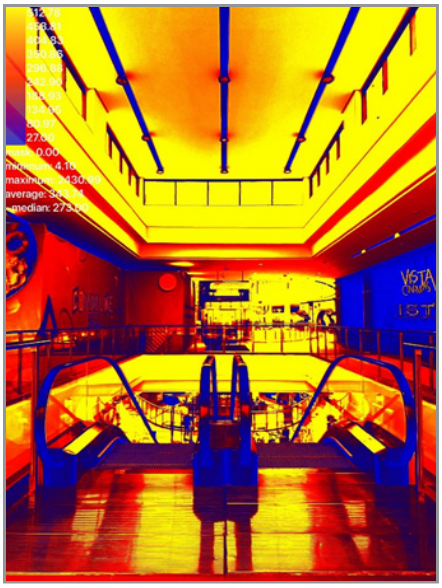
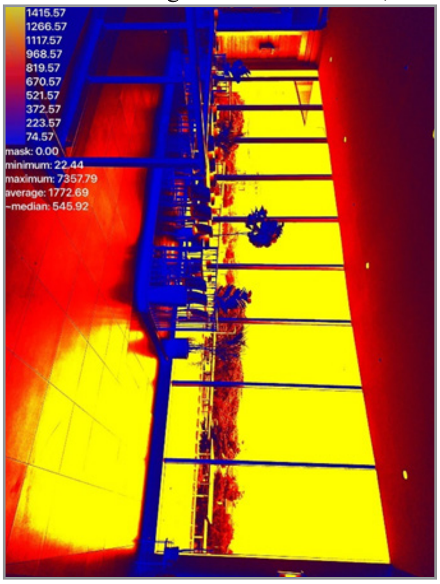


(c) 3:30 pm

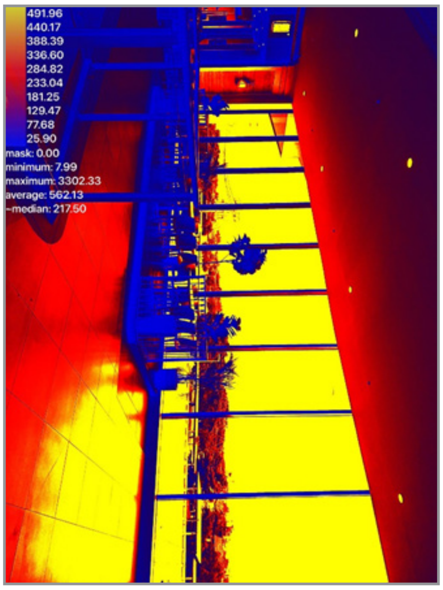


(d) 5:30 pm

Bacoor Mall Floor-to-Ceiling Windows – June 5, 2024



(a) 11:30 am



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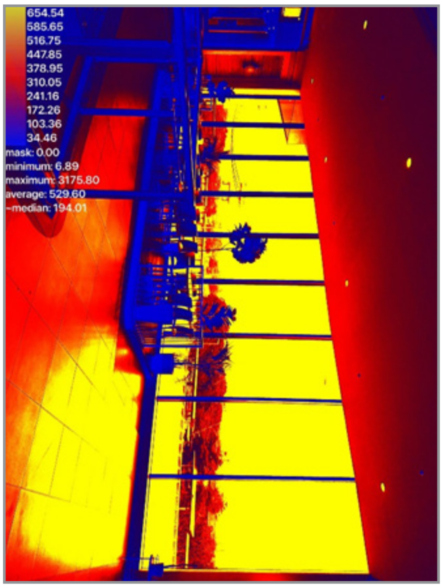

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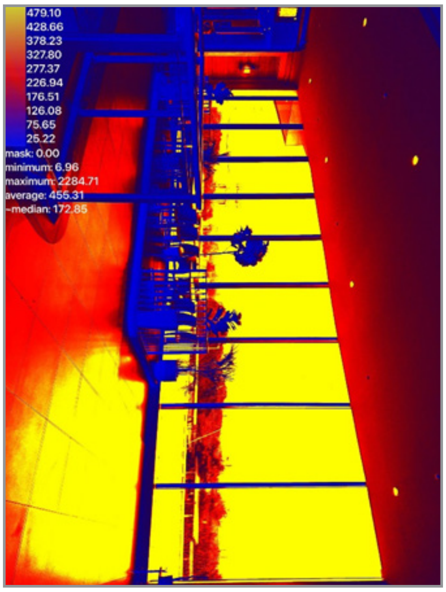

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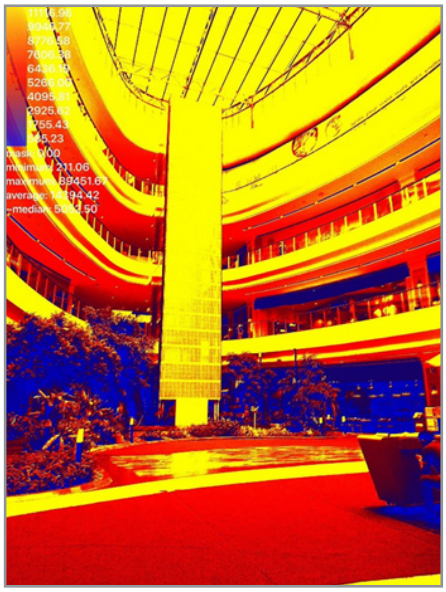

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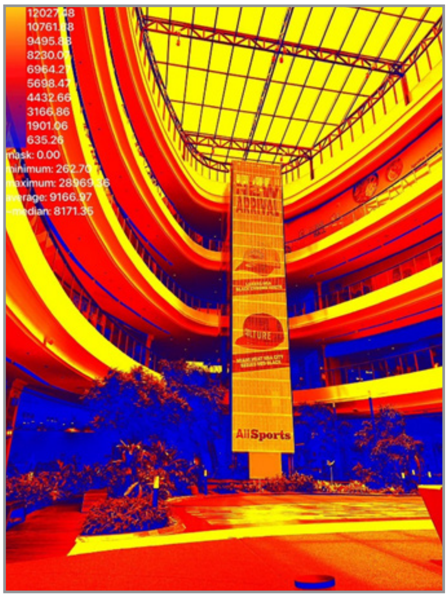
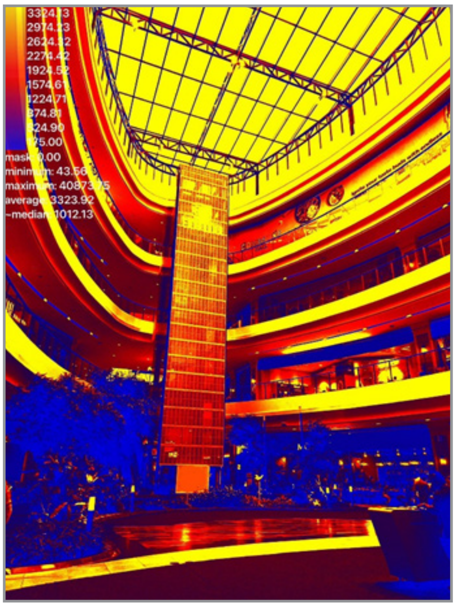
Bacoor Mall Skylight – June 7, 2024



(a) 11:30 am



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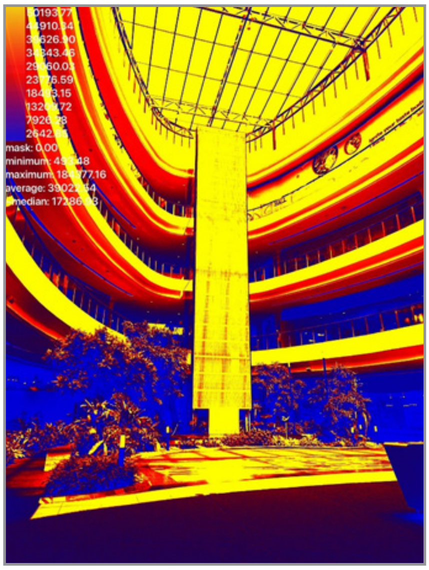
Bacoor Mall Clerestory – June 7, 2024



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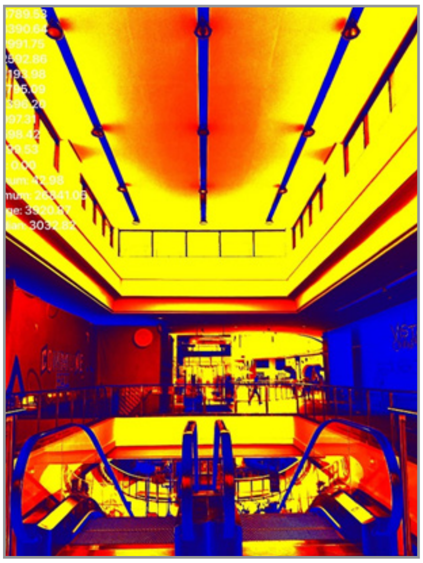

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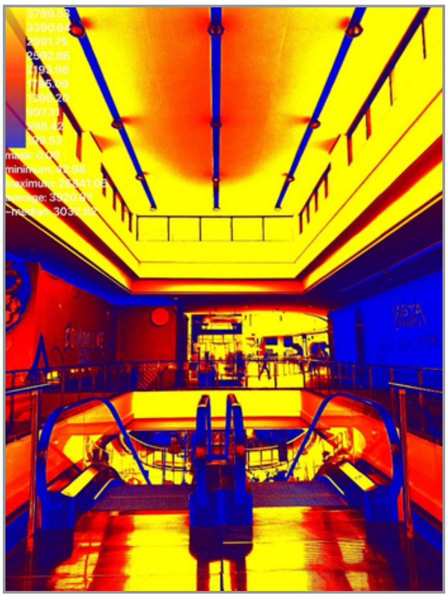
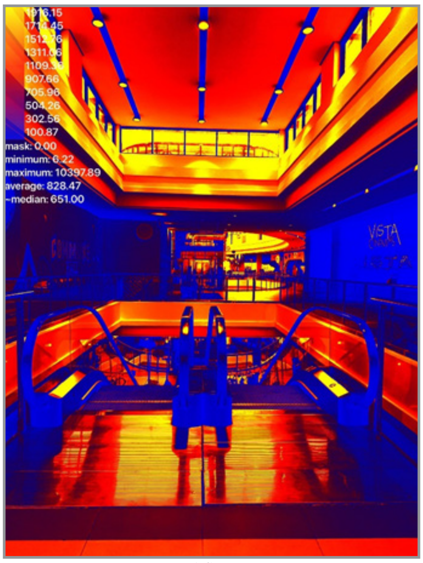


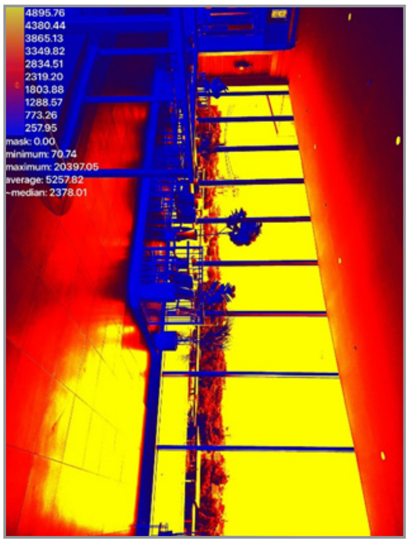
(b) 1:30 pm

(c) 3:30 pm

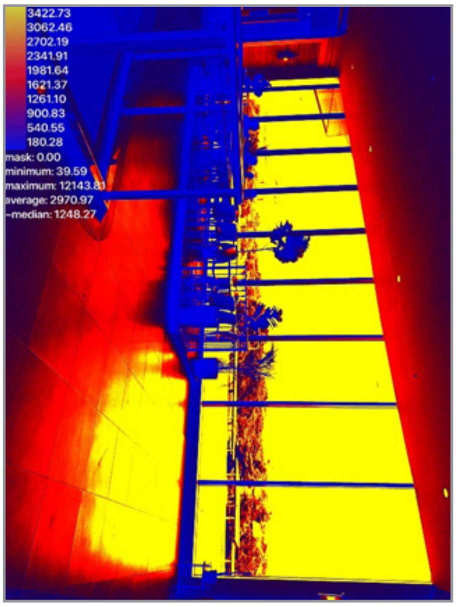


(d) 5:30 pm

Bacoor Mall Floor-to-Ceiling Windows – June 7, 2024



(a) 11:30 am



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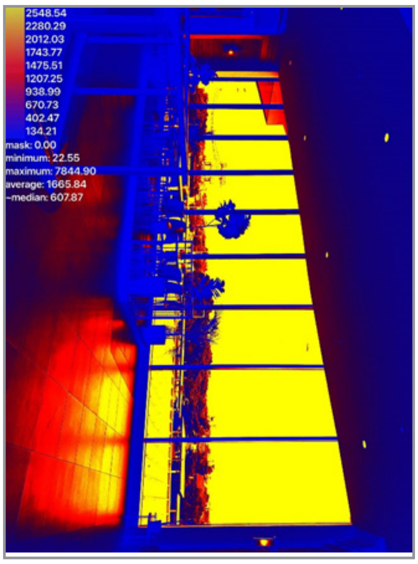

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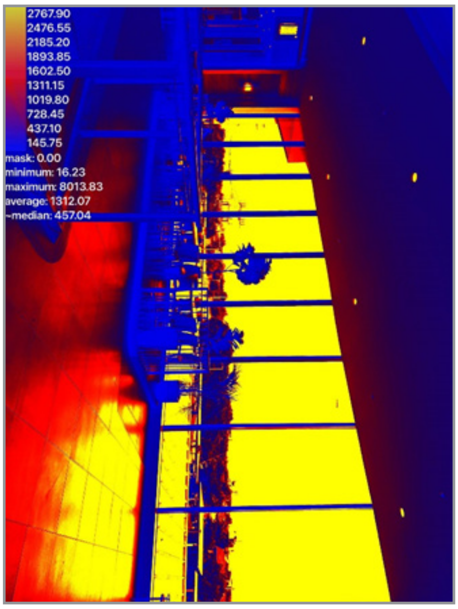
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maximum: 8013.83
average: 1312.07
~median: 457.04

(d) 5:30 pm