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Satisfaction Analysis of Atrium Day Lighting in Jordanian Residential Building

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Abstract:

Globally, daylight is an important issue in the modern architecture. Since, it affects the functional arrangement of spaces, occupant comfort, structure, and energy use in the buildings. Locally, in Jordan, there is a lack of studies that deal with architectural and interior design efforts to address the indoor daylight quality in houses. Also, Atrium houses are not widely spread in Jordan. The study aimed to; measure the satisfaction levels of atrium roof residents with daylight at Jordan in terms of interior design suitability, thermal comfort, and interior visual comfort. Methodologies: The research methodologies are quantitative and cross-sectional ones. The study conducted in Amman, Jordan. A sample of (355) respondents filled the self-administration questionnaire properly. The questionnaire had been developed based on previous studies, and its validity and reliability were done. Results: The study concluded that, Jordanians were satisfied regarding the daylight in their atrium roofs in terms of interior design suitability, thermal comfort, and interior visual comfort. The research findings suggest that Atrium Day Lighting in Jordanian residential building is crucial to be analysed and it is also significantly dependent on the identified factors; the interior design, thermal comfort as well as the vision comfort. All of these factors help the related residential sites constructors to have an insight about the factors that need to be focused upon while designing.

Keywords — **Satisfaction, Residential, Day Lighting, Atrium**

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I. INTRODUCTION

Jordan in the recently years of twentieth century has observed an inclusive evolution which is attended by comprehensive of urbanization in most of Jordanian cities, which made shifts in the Jordanian architect thought and committing in and the evolution of astonishing architectural styles and modern types of buildings [1]. Houses environments current exceptional challenges incessantly, several studies that are regarding to indoor environments quality design present a progressive dissatisfaction from houses environment, such as visual comfort, lighting, thermal comfort [2]. The findings of different studies show that daylight vulnerability may have an effect on human health, state of mood, well-being, productivity, and satisfaction [3], [4], [5]-[6]. Daylight backing our circadian rhythms, cures Seasonal Affective Disorder (SAD), and commences the synthesis of vitamin D [7], [8], [9], [10], [11]-[12]. However, there is a lack of studies in Jordan that deal with architectural and interior design efforts to address the indoor daylight

quality in houses. [13] and [14]. In fact, Jordan have need of intensive research to indoor environments quality issue such as lighting in rooms, daylight level, and other mandatory situations for residential satisfaction.

This study examines the effect of daylight design features on the level of domestic satisfaction with daylight in residential buildings with the Atrium roof in Jordan. Based on the quality of the visual environment of the interior space, and the comfort of their occupants, satisfaction and performance of perceived in thermal comfort and daylight suitability with interior design, to examine the effectiveness of daylight design and systems integration.

The specific aims of this study were to:

- To measure the satisfaction level on thermal comfort in atrium roof houses at Jordan.
- To evaluate the satisfaction level of atrium roof residents about the indoor environment quality of the interior visual comfort at Jordan.
- To measure the interior design suitability satisfaction level of atrium roof residents with daylight at Jordan.

A. Thermal Comfort (T.H)

Indoor environment quality covers numerous issues for daylight quality comprises thermal comfort, and daylight entry. Consequently, achieve perfect daylighting in the inside public area particularly of residential buildings can improve air quality and reduce the thermal levels towards realize comfort inside spaces [15]. Providing thermal comfort is one of the key objectives for daylighting design. Massive glazing areas could consequence in large heat transfer via conductance and solar radiation [16]. Recently, there has been revived consideration on the thermal indoor environment and potential nonvisual effects of daylighting in residential buildings [17] as part of an action towards sustainable buildings with a concentrate on user well-being. Active houses [18], No thermal environment can satisfy everyone because of individual differences in experiencing thermal environments the individual differences in thermal comfort responses are well known, but the differences between male and female subjects are considered to be limited [19].

B. Visual Comfort (V.C)

Comforts are intertwined as design criteria. Comfort has been defined as the state of mind which expresses satisfaction with the thermal environment. It is. Also, defined as a condition in which a specified percentage of people are anticipate to not express dissatisfaction ordinarily a percentage of 80% is used for predicting visual comfort [20].

nevertheless, there are detach metrics to acknowledge, comprise luminance ratio, daylight distribution, daylight glare index, illuminance on task level, etc. Visual comfort is associated with direct sun, superficial luminance, the absenteeism of glare, etc. considering the visible light source and luminance ratio in the range of view, a given design should not motivate glare and eyestrain. In a comfort study conducted by J Mardaljevic (2009) [21] on New York Times Headquarters using Radiance simulation, thermal comfort was established on the metric of Percentage People Dissatisfied (PPD) whilst visual comfort was the criteria of visual comfort with adding of view criteria. A view criterion was confined to shades raised and a pure vision without the presence of any fabric. According to Tregenza, there is guidance, listed below, to maintain visual comfort [22].

(1) Lighting standards recommendations (2) Optimal light distribution (3) Minimum luminance level (4) Acceptable glare level (5) Appropriate color temperature (6) Lighting uniformity values for different tasks (7) Avoidance of shadows and veiling reflectance (8) Proper luminance ratio [23]).

The researcher measured the resident's satisfaction level of the most of these recommendations in

terms visual comfort and interior factors that effect on it.

C. Interior and Daylight Suitability (I.D)

Construction is the generator of form and space. The structural configuration needs to be formulating in a method that it takes into consideration the interior layout and spatial arrangement rather than just bossy the building design. The external wall, or the structural layer, requirement to be planned from the interior as well as the external in terms of shaping space and bringing in daylight. [24] and [25].

Rider [26] and Bacon [27] defined sustainable interiors as interiors designed in such a technique that they reasonably address the impact of all their task, parts and constituent on the global environment.

Important element connected interior design is the use of daylight and as a consequence providing a connectedness to the natural environment. Daylight can often be defined as the practice of bringing light into a structure interior and distributing it in a way that provides more advantageous and preferable quality illumination than synthetic light sources [28].

When daylighting is skillfully designed it is an aid to efficient working and/or delectation of a space, and its directional qualities can assist resident in discerning details. Encourage natural lighting will increase the life quality of the users of internal spaces in the building [29].

II. METHODOLOGY

The Researcher choose Amman the place of study because the highest present of population and atrium roof buildings existing in Amman, Study will conduct in Amman-Jordan from November 2018 until March 2019. And the population for this study in Amman area will be 4582 listed in the ministry of public work housing [30].

Self-administration questionnaire used in this study and Questions were framed to evaluate the satisfaction level of atrium houses resident about thermal and visual comfort interior and daylight suitability and demographics. A pilot survey was conducting to 50 respondent's atrium house residents before the study start date to ensure effectiveness

The questionnaire consists of 23 items divided into three parts, the first of which is the level of satisfaction of the "interior design fit" with daylight and includes 8 items adopted from [31] and [32] and second part to measured satisfaction level about thermal comfort and includes 7 items adopted from [33], [34]-[35]

The latter measures the degree of resident's satisfaction level in visual comfort and includes 8 items adopted from [36] and [37] all of the satisfaction questions were adopted from multiple existing, tested and published survey tools.

Both open-ended and closed-ended questions were included on the questionnaire, Satisfaction responses were collected through a 5-point Likert scale ranging from 1 (very often disagree) to 5 (very strongly agree).

Reliability of the questions in statistical analysis, Cronbach's alpha is commonly used to estimate the reliability the questions were tested by this coefficient. The Cronbach's alpha coefficient estimated the internal consistency of the scales, and the values concerning variables. Visual comfort, thermal comfort and Interior and Daylight Suitability were .8415 and .8543 and .9238, respectively. The acceptable value of the alpha has been announced in different studies as ranging from 0.60 to 0.95. The coefficients in our study were both above 0.60, representing good reliability.

III. RESULTS AND DISCUSSION

A. Demographic variables Statistics

1) Gender:

The research involved (355) respondents in Amman -Jordan, of which there were fewer

female respondents (Nf = 143; 40.3%) and more members of the male sex participants (Nm = 212; 59.7%).

2) Age:

Respondents were grouped into (7) groups according to their age intervals from 25 years or less to above 50 years as shown in table 1

TABLE 1
STRUCTURE OF THE SAMPLE WITH RESPECT TO THE AGE GROUP

Age group	N	%
25 or less	4	1.1
26-30	10	2.8
31-35	54	15.2
36-40	67	18.9
41-45	74	20.8
46-50	51	14.4
Above 50	95	26.8
Total	355	100

3) Roof types

Roof types selected for the purpose of the research were divided into five groups which descriptive are presented in table 2. Ridge Roof type has the largest share percentage in total roof types included in the research (68.2%).

TABLE2
TYPE OF THE ROOF STRUCTURE DESCRIPTIVE

Roof Type	N	%
Ridge	242	68.2
Pyramid	20	5.6
Barrel vault	22	6.2
Polygon	37	10.4
Ridge with gable ends	34	9.6

B. The answers to the research questions

Table 3 shows that respondents are satisfied with Atrium Day Lighting in Jordanian Residential Building (M= 3.91, SD = 0.297), also respondents are satisfied with each subscales of Atrium Day Lighting in Jordanian Residential Building. Namely, these subscales are; firstly: "interior design" suitability in atrium roof resident's with daylight at Jordan subscale (M = 3.91, SD= 0.369), secondly, "thermal comfort" to atrium roof residents with daylight at Jordan subscale (M = 3.86, SD = 0.427), and finally, indoor environment quality of the interior "vision comfort" at Jordan subscale (M = 3.97, SD = 0.354).

Table 3
DESCRIPTIVE STATISTICS REGARDING THE SATISFACTION LEVEL OF ATRIUM ROOF RESIDENTS WITH DAYLIGHT

Subscale	N	Min	Max	M	SD
Interior Design	355	2.25	5.00	3.91	0.369
Thermal Comfort		2.29	5.00	3.86	0.427
Visual Comfort		2.50	5.00	3.97	0.354
Total Score		2.35	5.00	3.9110	0.29741

C. The analysis of demographic variables on the respondents' responses'

1) Gender:

Male respondents' satisfaction score for interior design suitability in atrium roof resident's with daylight subscale is higher than the female respondent's satisfaction score, while it is reversed when it comes to thermal comfort to atrium roof residents at Jordan with daylight where females' respondent's satisfaction scores slightly higher satisfaction scores of male respondents. On the other hand, equally male respondents and female respondents have the same satisfaction score in

Regarding to the indoor environment quality of the interior visual comfort a t-test was conducted to test if there is a statistically significant difference in the satisfaction score of respondents' perceptions of Atrium Day Lighting in Jordanian Residential Building subscales in according to the variation in respondents' gender.

TABLE 5
T-TEST IN THE MEAN OF RESPONSES ACCORDING TO THE RESPONDENTS' GENDER

Subscale	t-value	Sig. (2-tailed)
Interior design	3.106	0.002
Thermal comfort	-1.259	0.209
Visual Comfort	-0.055	0.957

Table 5, shows that male respondents are more satisfied in regarding to interior design suitability with daylight subscale, than females' respondents' (M = 3.83, SD= 0.400), since (t = 3.106, p = 0.002). While there was no statistically significant difference in the satisfaction scores among females' respondents' and males' respondents' in their perceptions of thermal comfort (t= -1.259, p = 0.209) as well as visual comfort (t= -0.055, p= 0.957).

2) Age

Firstly, in regarding to the interior design subscale, the youngest respondents', whom age group is less than 25 years old (M = 3.63, SD = 1.155) are lowest satisfied, while the second age group, whom are only five years older than youngest respondents, are the highest satisfied (M = 4.28, SD = 0.175). In addition, respondents have the same satisfaction perceptions toward the thermal comfort subscale. Since the youngest group, whom age group is less than 25 years old (M = 3.71, SD= 0.165) is lowest satisfied, while the second age group, whom age group is between 26 – 30 years old, is the highest satisfied (M = 4.03, SD= 0.559). However, respondents' satisfaction does not follow the same pattern as the interior design subscale and thermal comfort subscale perceptions, since the third age group, who ages are between 31-35 years old, are the lowest satisfied (M=3.91, SD= 0.209), and the second age group, whom ages are between 26-30 years old, are the highest satisfied (M =4.10, SD=0.562). The ANOVA test was conducted to test if there were a statistically significant difference in satisfactions scores according to their age groups variations, Table 6.

TABLE 6
THE VARIANCE ANALYSIS (ANOVA) OF AGE GROUPS ON THE SATISFACTION SCORE OF RESPONDENTS

CO.	Source of variance	Sum of Squares	df	M	F	Sig.
I.D	Between Groups	2.81	6	0.468	3.589	.002
	Within Groups	45.412	348	0.13		
	Total	48.222	355			
T.C	Between Groups	0.598	6	0.1	0.542	.776
	Within Groups	64.014	348	0.184		
	Total	64.612	355			
V.C	Between Groups	0.796	6	0.133	1.061	.386
	Within Groups	43.519	348	0.125		
	Total	44.315	355			

Table 6 shows there are statistically significant differences among age groups on the interior design subscale (F= 3.589, p= 0.002). On the other hand, there were no statistically significant differences of age groups on thermal comfort subscale (F=0.542, p= 0.776), nor on visual comfort subscale (F=1.061, p= 0.386).

However, since there was a statistically significant difference of age groups on the interior design subscale, a Post hoc analysis, Least Significant Difference test (LSD), was done in order to identify where the differences do occur. LSD analysis of age groups impact on the satisfaction score of Atrium Day Lighting in Jordanian Residential Building are presents in table 7.

TABLE 7
THE LIST OF STATISTICALLY SIGNIFCANT DIFFERENCES AMONG AGE GROUPS THEIR SATICFACTION SCOUR ON INTERIOR DESIGN

Dependent Variable	(I) age	(J) age	Mean Difference (I-J)	Std. Error	Sig.
Interior design	25 OR LESS	26-30	0.650(*)	0.214	0.003
	26-30	31-35	0.386(*)	0.124	0.002
	26-30	36-40	0.413(*)	0.122	0.001
	26-30	41-45	0.405(*)	0.122	0.001
	26-30	46-50	0.442(*)	0.125	0.000
	36-40	above 50	0.125(*)	0.058	0.031
	41-45	above 50	0.117(*)	0.056	0.038
	46-50	above 50	0.154(*)	0.063	0.015

Table 7 shows the difference in satisfaction score occurs mostly between the second age group, whom ages are between 26-30 years old, and others age groups; 25 OR LESS (p = 0.003), 31-35 (p = 0.002), 36-40 (p = 0.001), 41-45 (0.001), 46-50 (p = 0.000), and between the oldest group (above 50 years old) and others age groups; 36-40 (p = 0.031), 41-45 (p =0.03), and 46-50 (p = 0.015).

3) Roof type

Table 8 shows the satisfaction scores on each subscales of Atrium Day Lighting in Jordanian Residential Building questionnaire are closed to mean satisfaction score for its corresponding subscales in spite of roof type; Ridge, Pyramid, Barrel Vault, Polygon, and Ridge with gable ends. It is worth able to say that the "Ridge" roof type is the most frequent in Jordan (N = 242), while others type was less frequent in Jordan.

In order to find if there a statistically significant difference in roof type on the satisfaction score of Atrium Day Lighting in Jordanian Residential Building, the researcher conducted the variance analysis, ANOVA. Table 8 shows the ANOVA results of roof type on the satisfaction score of Atrium Day Lighting in Jordanian Residential Building subscales.

TABLE 8
THE VARIANCE ANALYSIS (ANOVA) OF ROOF TYPE ON THE ATRIUM DAY LIGHTING IN JORDANIAN RESIDENTIAL BUILDING SUBSCALES

Co.	Source of variance	Sum of Square	Df	M	F	Sig.
I.D	Between Groups	.469	4	0.117	0.860	.488
	Within Groups	47.752	350	0.136		
	Total	48.222	354			
T.C	Between Groups	.431	4	0.108	0.588	.672
	Within Groups	64.181	350	0.183		
	Total	64.612	354			
V.C	Between Groups	.470	4	0.118	0.938	.442
	Within Groups	43.845	350	0.125		
	Total	44.315	354			

Table 8 shows there are no statistically significant differences of roof type on the satisfaction score of respondents on Atrium Day Lighting in Jordanian Residential Building subscales. Consequently, since there were no statistically significant differences of roof type on the satisfaction score of respondents on Atrium Day Lighting in Jordanian Residential Building subscales, Post Hoc analysis not required and it not conducted

IV. CONCLUSION

The research is about examining the Atrium Day Lighting in Jordanian residential building and it was crucial to analyses this aspect in the detail mainly because the customer satisfaction seem to vary with the residential construction. The demographic factors that were primarily focused upon included gender, age and the roof types. In addition to that, in order to find the motivating factors of the atriums, the three aspects had been focused upon in the research namely: interior design, thermal comfort as well as the vision comfort. It was found that age and motivation are

interrelated and it may vary from one age band to another. The selected age groups of the respondents ranged from 25 years or less, to above 50. Furthermore, the age is also a major factor that seems to have a positive or negative impact on the level of satisfaction.

On the other hand, the other two demographic variables of the study i.e., gender and roof type did not show any impact on the respondent's level of satisfaction. Of all the sub scales that had been selected for the research, the vision comfort was regarded as the most important element and it also displayed a high mean score. However, the other two factors were also given importance by the respondent's side by side. Similarly, the visual comfort subscale also tends to perform lowest variation in the respondent's responses which leads to the higher stability and consistency of the subscale. Therefore, it could be extracted upon examining the overall research findings that the Atrium Day Lighting in Jordanian residential building plays a fundamental role in the region and could be further researched in the future by relating the subject to the other domain areas. This would also allow in unraveling the interplay of the other additional mediating factors.

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