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## THE IMPACT OF VISUAL ENVIRONMENT ON ILLUMINANCE LEVELS PREFERENCE CROSS-CULTURE CASE STUDY ON OMANI AND PORTUGUESE FORTS IN OMAN

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## Abstract

The objective of this research is to investigate the cross-cultural differences with regard to the illuminance levels preferences. Illuminance level preferences are directly related to and based on visual environment impact that differs according to different geographical locations. Therefore, the cross-cultural difference is a common term that relates directly to the different visual environment of each region. Toward this aim a field study carried out a comparison of daylight illuminance levels of internal spaces, in a definite region (Muscat, Oman), built and used by two groups of people from different climatic and cultural backgrounds. Forts and citadels built and inhabited by Omanis and Portuguese in Muscat region represent a good case study to test the stated hypothesis. The two inhabitant groups are from totally different climatic and luminous environments that directly affecting their perception and need of daylight; that is regarding their long-term adaptation to natural light level of their regions. The comparison utilized a hypothetical framework of lighting preferences to compare the similarities and differences in visual attributes between the mentioned cultures. Findings confirm the influence of climatic and cultural backgrounds on lighting levels preference that show that the lighting preferences are not universal. Accordingly, the global standards of lighting levels recommendations might be NOT suitable to be applied all over the world regardless the difference of environmental impact on human adaptation. These findings are useful to practitioners who are designing to effectively address the diversity of user's lighting levels preferences in our globally connected society.

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Eissa, Hesham T.<sup>1</sup>

## **Abstract**

*The objective of this research is to investigate the cross-cultural differences with regard to the illuminance levels preferences. Illuminance level preferences are directly related to and based on visual environment impact that differs according to different geographical locations. Therefore, the cross-cultural difference is a common term that relates directly to the different visual environment of each region. Toward this aim a field study carried out a comparison of daylight illuminance levels of internal spaces, in a definite region (Muscat, Oman), built and used by two groups of people from different climatic and cultural backgrounds. Forts and citadels built and inhabited by Omanis and Portuguese in Muscat region represent a good case study to test the stated hypothesis. The two inhabitant groups are from totally different climatic and luminous environments that directly affecting their perception and need of daylight; that is regarding their long-term adaptation to natural light level of their regions. The comparison utilized a hypothetical framework of lighting preferences to compare the similarities and differences in visual attributes between the mentioned cultures. Findings confirm the influence of climatic and cultural backgrounds on lighting levels preference that show that the lighting preferences are not universal. Accordingly, the global standards of lighting levels recommendations might be NOT suitable to be applied all over the world regardless the difference of environmental impact on human adaptation. These findings are useful to practitioners who are designing to effectively address the diversity of user's lighting levels preferences in our globally connected society.*

## **KEYWORDS:**

Illuminance level preference, cross-culture difference, daylight, visual environment, long term visual adaptation, visual perception.

## **RESEARCH OBJECTIVE**

The hypothesis of this research is to confirm the cross-cultural differences in illuminance levels preferences by utilizing a new approach that investigates spaces in historical buildings. Such historical buildings would give a reliable measure as the contribution of daylight into the living spaces was sole and essential. Architecture practice then deeply respected the only source of abundant light. Comparing the architectural spaces built and used by different groups of people coming from different cultural and climatic backgrounds living in the same geographic location; that will verify the assumption of cross-cultural differences in light levels preference.

In order to investigate this hypothesis, illuminance levels of several living spaces in ancient forts located in Oman were measured. Some of these forts were built by the local Omani citizens whereas others were built by Portuguese in the coastal areas during their rule in Oman (1508–1648 A.D.).

## **BACKGROUND**

Globalization creates unique cultural challenges since standards and design solutions often cannot be universally applied to different cultural contexts (Davis et al. 2007). Therefore, a persuasive design requires knowledge-based design decisions about user preference. In the same path, Guerin and Mason (1993) suggested, interior designers need to be culturally sensitive to face design challenges in an increasingly international world. By knowing a culture, a designer can begin to understand the preferences of their users.

Several studies have included mood or satisfaction ratings in order to determine which lighting conditions are preferred. Creating conditions that people prefer, to satisfy them and make them comfortable, is a major goal of lighting design.

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Lighting conditions that produce positive effect will influence cognitive task performance and social behaviors (Baron et al., 1992). The results showed that the good lighting conditions have positive effect on behavior. Many observers have noted differences in visual perception between people coming from different cultural backgrounds. On closer examination, these differences appear to be related to cultural factors rooted in geographical locations. There are researches that confirm the agreement on subjective evaluation of light schemes within the same culture that directly affects the people's mood (Flynn et al. 1973) and such agreement regarding subjective evaluation has been investigated even through computationally generated and rendered lighting schemes (Mahdavi and Eissa 2002), but not much research has been conducted on the cross-cultural differences in lighting preferences.

Most cross-cultural lighting studies examined preference of color temperature and did not focus on illuminance levels. However, Belcher (1985) argued that understanding cross-cultural illumination preferences is critical since it can affect users' wellbeing and mood. The results indicated that cultural background significantly influenced preference among different intensities and color temperatures of light. These findings confirm Belcher's hypothesis that cultural differences in illumination preference exist which may influence comfort, wellbeing, and consequently productivity. A review of cross-cultural preference studies suggests that similarities and differences of preference exist between cultural groups. Regarding qualitative measures, a moderate agreement among lighting practitioners about the quality of computer-simulated lighting designs; on the other hand; differences between cultural groups were also observed (Veitch & Newsham 1996). Although these studies provide substantial information regarding cross-cultural comparisons of environmental preference, their results remain largely unexplained because of a lack of elaborating theoretical frameworks. More clarifications have been suggested by Berlyne's theory that explains the biological process of environmental preference, he also stated that behavior resulting from psychophysical processes is culturally conditioned (Berlyne 1971). That consequently includes the visual perception in general and illuminance preferences in particular. Rune Pettersson (1982) indicated that the human's color perception varies according to different lighting conditions. That will be mostly true regarding the illuminance level perception as well. The locations that differ in latitude have different illumination levels over the year.

Therefore, human long term adaptation to different light condition does exist. Thus, people live on equator areas, for example, are ecologically adapted to life in a climate characterized by bright sunlight. Consequently bright light cause all colors and contrasts tended to decline in intensity as bright sun high in the sky casts dark shadows. Therefore, people evolving in such environment developed black/white vision (i.e., a large number of efficient rods in their retinas) should be advantageous to survival. On the other hand, as latitude increases in the colder climates to the north and south, large parts of the day consist of various phases of dawn or dusk. People live in those climates developed color vision where the environment is rich in colors. (Pettersson 1982)

Earlier literature confirmed same concept; the biological difference in people regarding their long term adaptation to the local visual environment consequently exists. Bornstein (1973) indicated that people living nearer the equator are likely to have more yellow intraocular pigmentation. Also different reviewed studies showed that people having more ocular pigmentation display reduced sensitivity at the short wavelength side, particularly in the blue area. The cultural factors in a geographic location appeared to cause differences in visual perception as well. The prior research findings suggest that biological factors and cognitive factors have an important influence on illumination preferences and consequently on design attributes. From here we started our investigation of the significant effect of the cross-cultural differences in buildings' design and particularly on the visual aspects in living spaces.

## RESEARCH METHODOLOGY

The research involved three main phases: indicative, investigative and diagnostic phases.

**The indicative phase** valid spaces for field study were selected and their initial information related to the location and historical background, in addition to the climatic data of the regions of the habitants were covered in this phase.

**The investigative phase** of the research focused on field-based data gathering and measurements over period of two months: January and February. Those months have been selected as they represent the lowest illuminance level across the year in Oman that make the comparison with the standards more relevant. The information identified lighting conditions of the spaces under controlled conditions (at noon time, under clear sky conditions for all spaces).

**Finally, a diagnostic phase** of the research involved data analysis, results, and conclusions. The information provided from this phase allowed a development of a comprehensive analysis including comparison of the conditions that lead to the hypothesis examination. Also, in diagnostic phase conclusions were diverted from data analysis and general observations. These conclusions highlighted the cross-culture comparison of the ancient occupants of the selected spaces.

## INDICATIVE PHASE

### *Space sample selection*

Since the objective of this study is to investigate the cross-cultural difference in lighting preferences, and to avoid the climatic changes across regions, the forts were chosen from same region (Muscat), currently the capital of Sultanate of Oman. The significance of the selected region is that it contains number of forts were built by two different inhabitants coming from different geographical and climatic environments. Those inhabitants are from Oman and Portugal (Location of both places are indicated in figure 1).

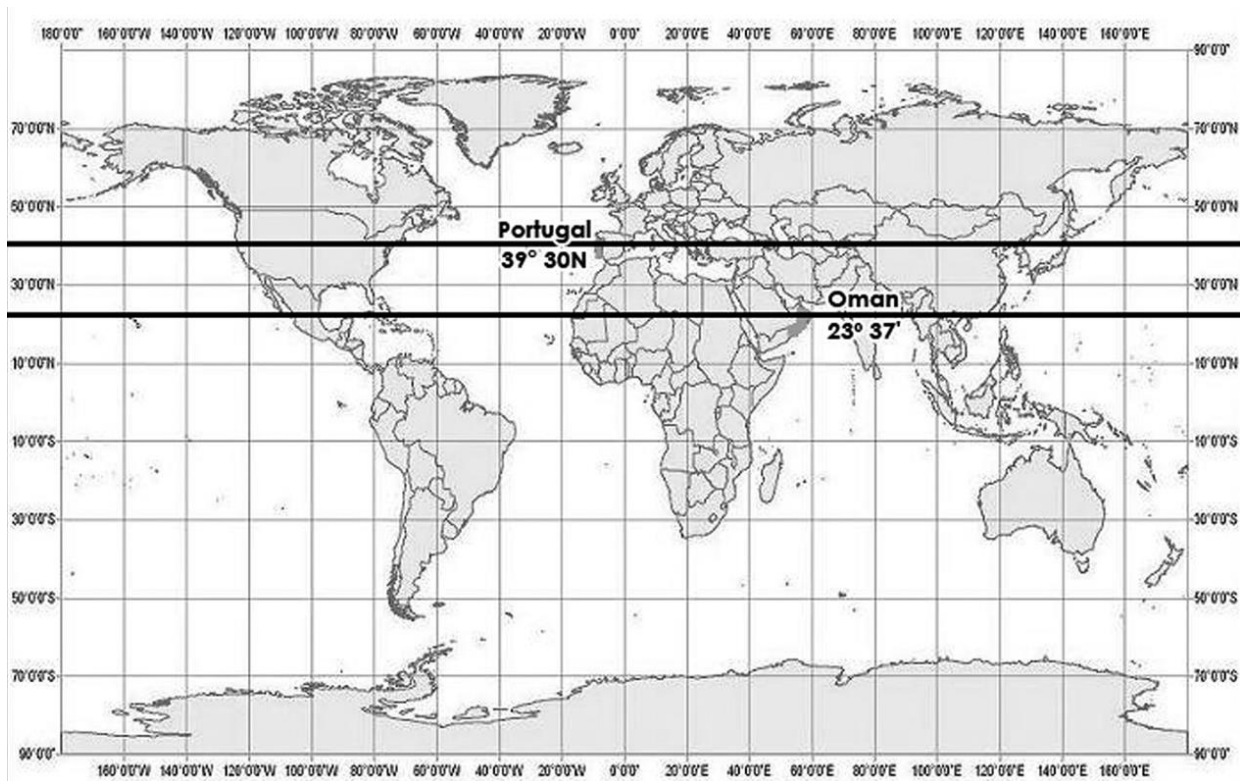


Figure 1: Location of Muscat (Oman) and Lisbon (Portugal), The longitude and latitude values of Muscat, and Lisbon respectively: (58° 38' E, 23° 37' N) and (8°W, 39° 30' N) (Cities locations plotted by author).

The Portuguese occupied Muscat for a 140-year period from 1508 to 1648 A.D., arriving a decade after Vasco da Gama discovered the seaway to India. They fortified the city on costal line in order to protect their sea lanes, some of these forts still exist. The geographical and climatic information of both countries are investigated in this phase, in order to compare the differences and similarities of both inhabitants.

### *Selected spaces overview (Forts in Muscat area)*

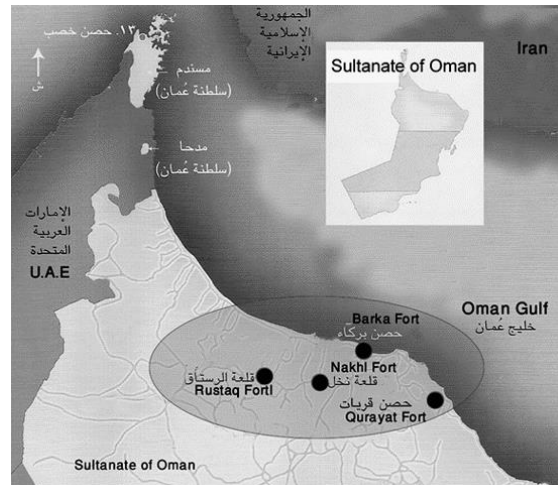
Four forts and citadels were chosen from Al-Batinah region (Muscat), which are: Qurayat, Barka, Rustaq, and Nakhl forts. Qurayat and Barka fort were built by Portuguese on the coastline whereas Rustaq and Nakhl forts were built by Omani citizens in the interior part of Al-Batinah region (Figure 2). Five spaces are tested out of those four Forts. All selected spaces lies under same climate conditions as explained further on.

**Climatic Data**

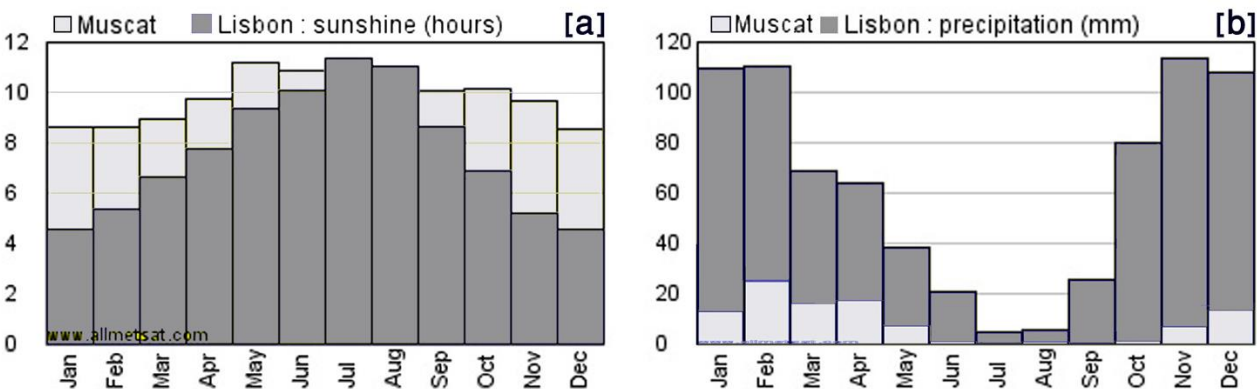
To have a valid comparison all light measurements took place in the months of January and February under clear sky condition. Therefore the daylight conditions are the same during that period. Oman has a hot climate and very little rainfall. Annual rainfall in Muscat averages 100 mm (3.9 in), falling mostly in January. The annual temperature in Muscat varies from 25°C (in January) to over 40°C (in June).

Portugal is defined as a Mediterranean climate and is one of the warmest European countries: the annual average temperature in Lisbon varies from 15 °C (December and January) to over 28 °C (July and August).

According to the previous information as Portugal is farther from equator than Oman, the latitude of Muscat and Lisbon are 23° 37' N and 39° 30' N respectively as shown in Figure 1. The light from the sun strikes Portugal in a smaller angle than Oman. Therefore, Portugal goes through various phases of dawn and dusk, so the sun is not bright throughout the day time like in Oman. When comparing the monthly average number of hours of sunshine per day, it can be seen that Oman experiences brighter days than Portugal and for a longer period of time (Figure 3). This comparison implies that citizens of these two countries are adapted to different illuminance levels as mentioned in the prior research. Further in this paper, the theory of different light preferences of users coming from different geographical locations will be tested.



**Figure 2: Chosen forts and citadels locations (Source: Citadels and Forts in Oman – Locations translated by Author)**



**Figure 3: Climatic Data for Muscat and Lisbon: a) Monthly average numbers of hours of sunshine per day; b) Monthly average of precipitation (source: Allmetsat.com – graphs combined by author)**

**INVESTIGATIVE PHASE (FIELD STUDY)**

In this phase, criteria have been defined to control variables then architectural and light measurements took place accordingly. Data gathered were arranged and plotted to be compared and analyzed in the diagnostic phase.

**Criteria set for field study**

The criteria used for the experimental work helped in controlling most of the variables influencing daylight illuminance in the selected lit spaces. By controlling these variables, they can be held constants thus the comparison would be limited to the illuminance level (daylight). That will make sure of valid comparison. All compared spaces were living spaces (Majlis), and all directed to the north direction to avoid sunrays penetration. Furthermore, all measurements took place, as mentioned previously, on December and January at noon time. Selected spaces were facing no external obstructions to have the same chance of having equal (more or less) sky component and avoiding the differences in illuminance that might happened regarding variation of the externally reflected component. Other criteria were examined and found controlled as the internally reflected component.

**Measurement Procedure and Work**

All illuminance level measurements took place in living spaces (Majlis) in the chosen forts (five spaces in four forts). In living spaces of the forts, reading and writing were considered to be the most common tasks that need adequate light and usually performed sitting.

Therefore, the working plane was considered at height of 40cm from the floor level (Figure 4). Therefore, the light-meter always placed on this height during the measurement process. Referring to international standards the minimum required illuminance level for such task (usually low detail, large size and high contrast) is 200 to 300lux in average according to (IESNA) handbook. Illuminance levels were measured using light meter, at intersection points of (50cm × 50cm) grid to have fine and reasonable distribution and at height of 40cm (Figure 4).

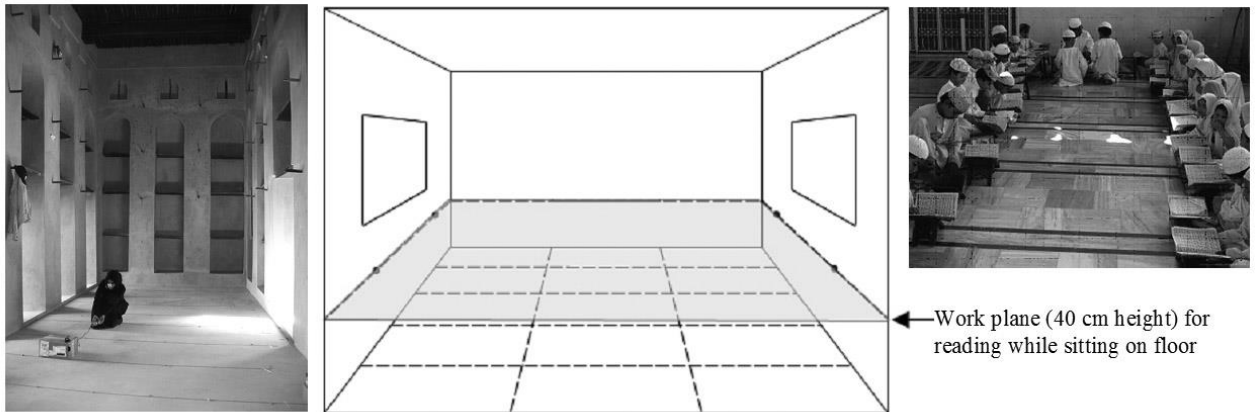


Figure 4: the work plane for reading and writing tasks in Arabic Majlis and illuminance levels measurement procedure (Measurements on site and author sketches)

The collected data of the measured illuminance levels points were loaded in spread sheets for evaluation and comparison. All detailed information of the selected spaces was recorded such as date, time, outdoor illuminance, indoor illuminance, and architectural data. Qurayat fort as an example for data collection and analysis procedure illustrated further on (Table 1 and Figure 5), also, isolux graphs (Figure 6 – Qurayat fort) were plotted accordingly. The measured space was a majlis (living space) located in the northern side of the fort. It has window openings from two sides, in the wall which was facing the north and the wall adjacent to the courtyard.

Space:	Majlis
Date:	15/02/2009
Time:	01:00 pm
Outdoor Illuminance:	13,550 Lx
Average Illuminance:	112 Lx
Daylight Factor (DF):	0.8 %
Window-Floor Ratio	15 %

Table 1: Qurayat Fort - Majlis space measurements (by author)

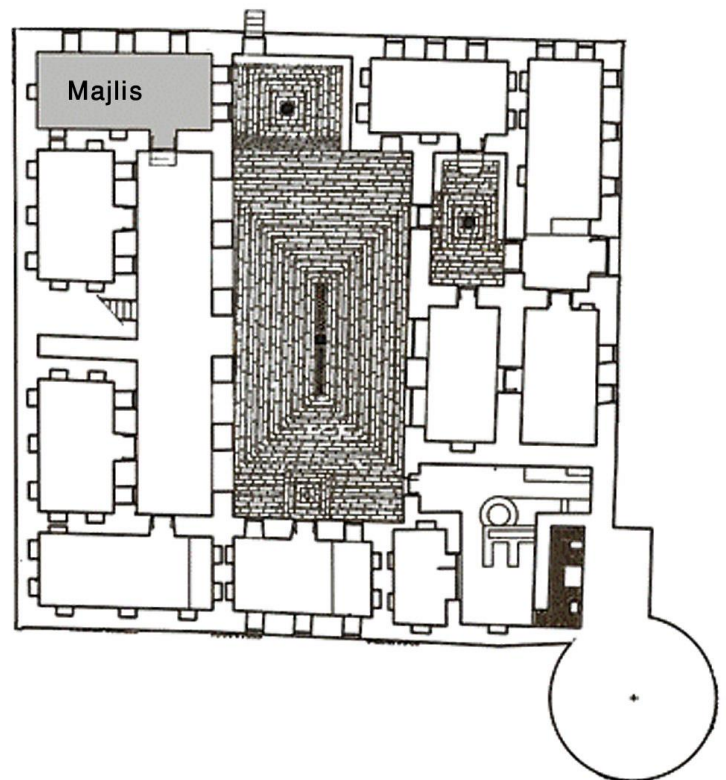


Figure 5: Qurayat fort – measured space location (Majlis) (Source: Citadels and Forts in Oman)

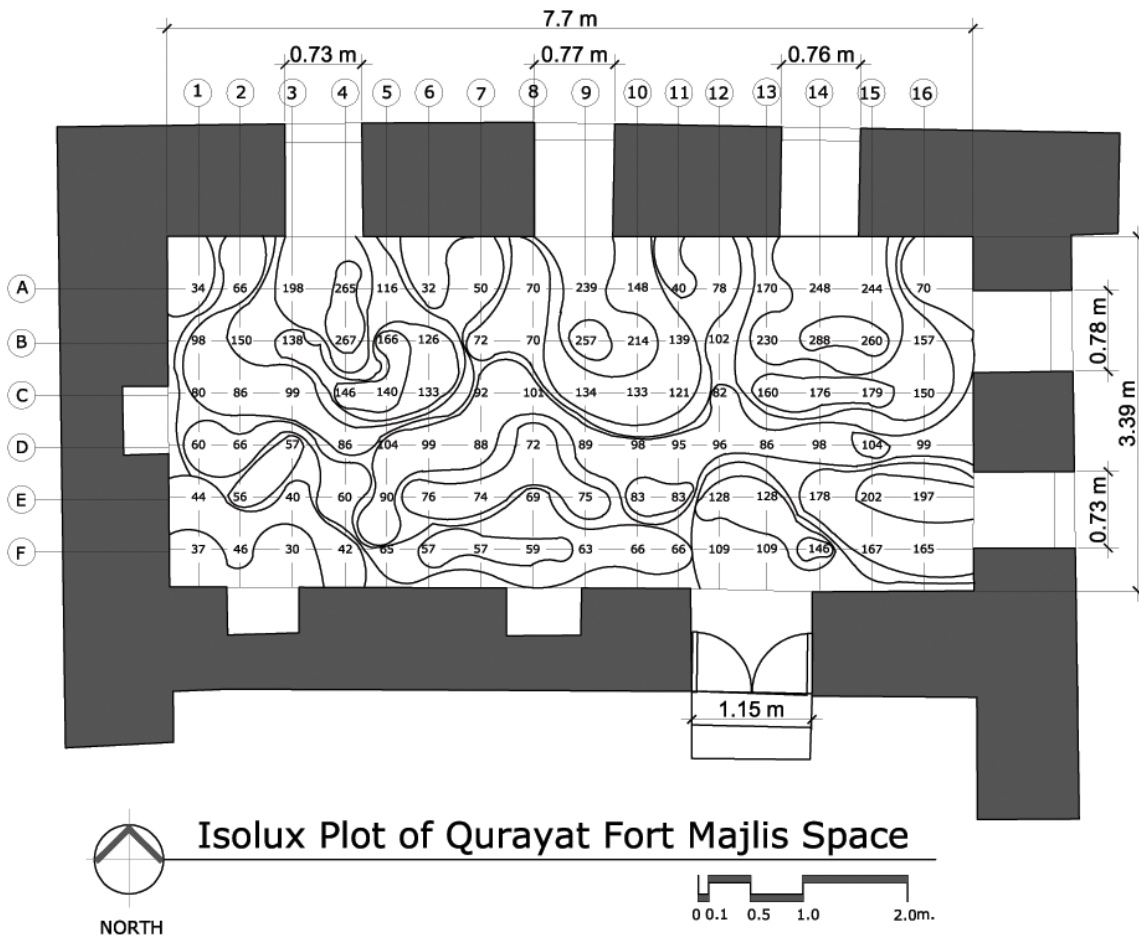


Figure 6: Isolux plot - Qurayat fort Majlis space that shows the illuminance levels variation across the space (by author)

All selected spaces were analyzed according to the daylight distribution as plotted in 3-D. Qurayat fort (figure 7) illuminance distribution was non-uniform across the space as light levels are widely varied (from 30 to 280 lux). However, the uniform distribution of illuminance is not expected in daylight measurements; regarding the light degradation in deeper areas away from the windows when relying on daylight. All spaces isolux plots in plans and 3-D illuminance distribution graphs are shown in table 2. the space as light.

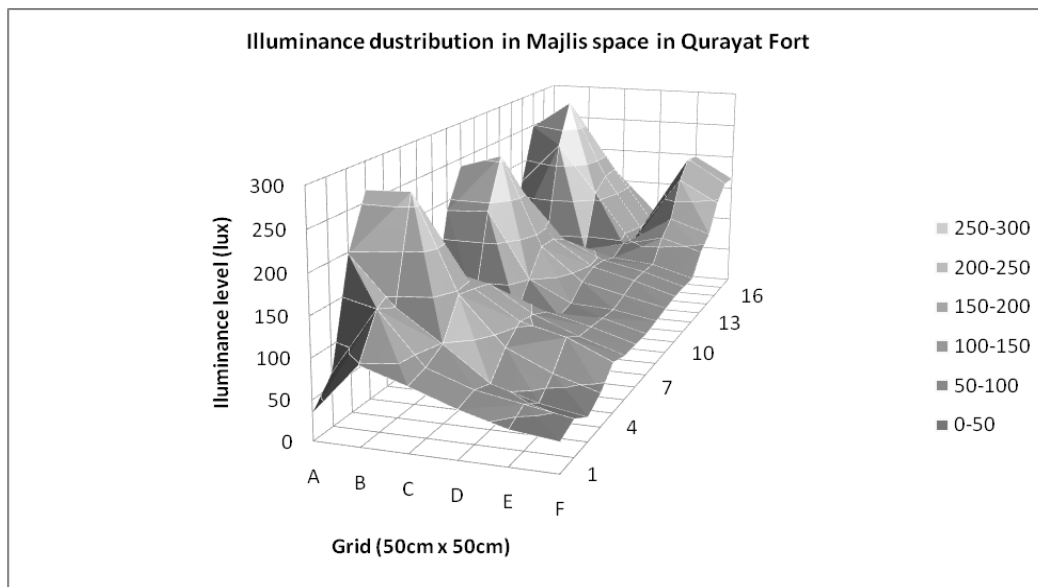
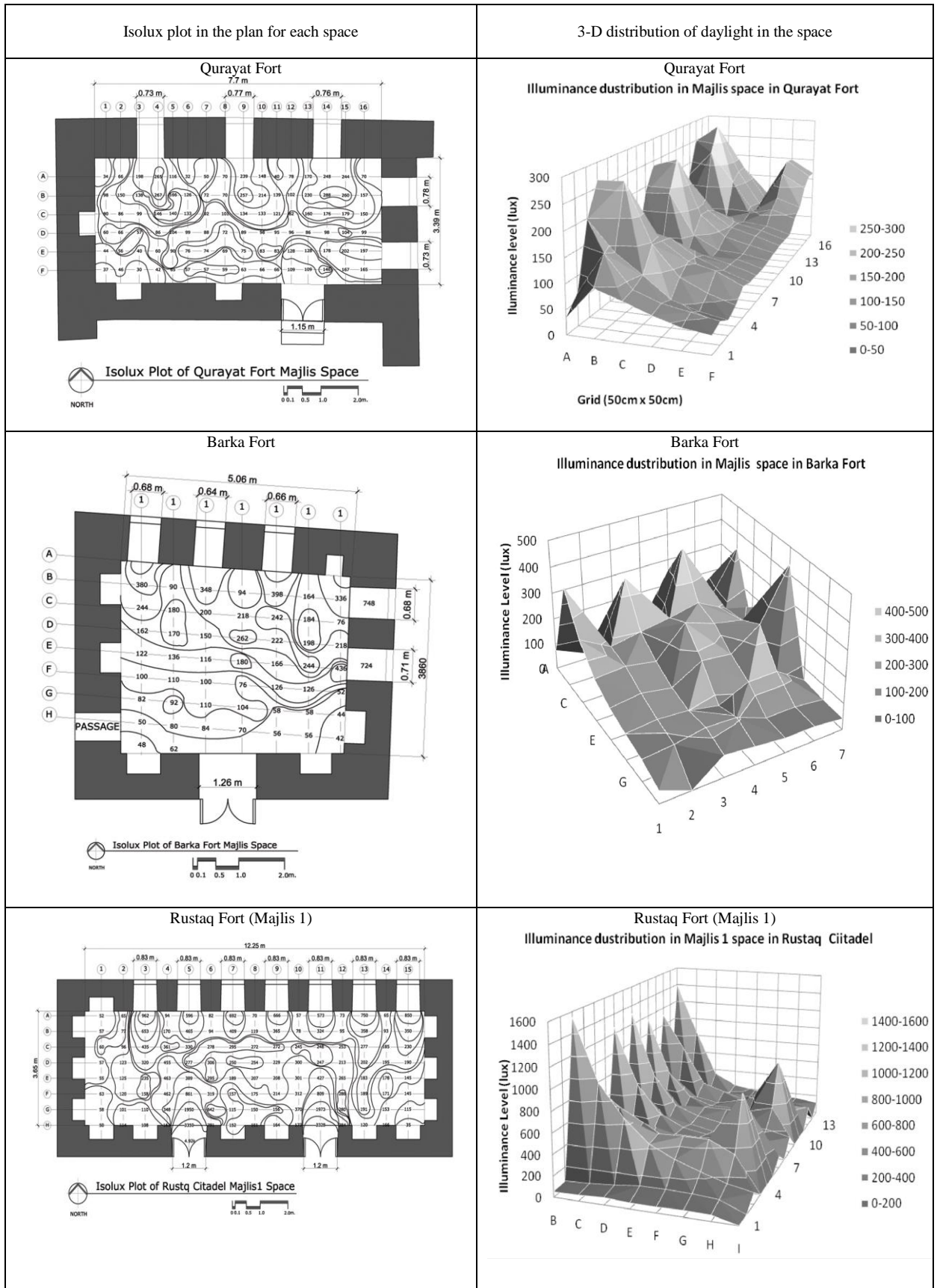




Figure 7: 3-dimensional distribution of natural light in the Majlis in Qurayat fort (by author)



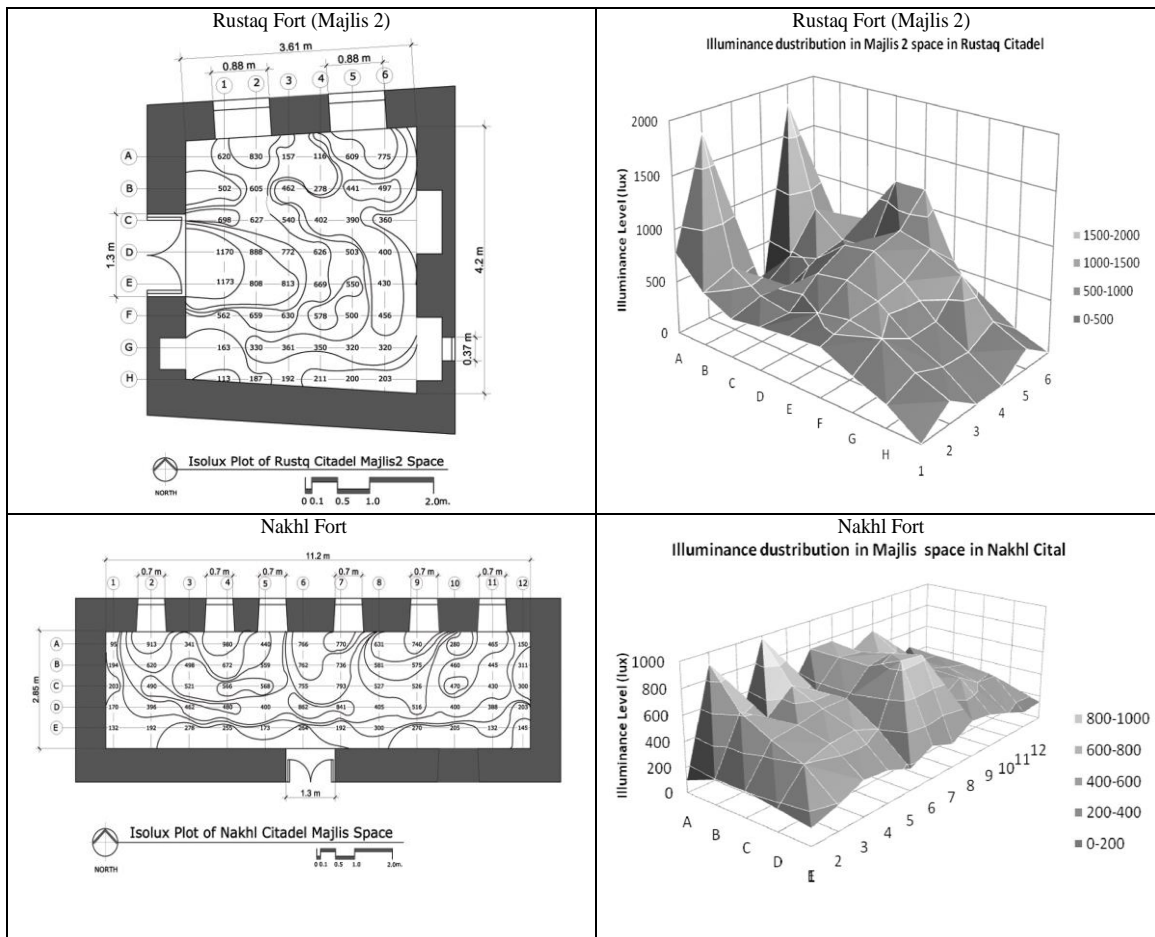


Table 2: 3-D illustration for illuminance distribution in all selected spaces (Isolux plots in plans and 3-D distribution of the daylight) (By author)

## DIAGNOSTIC PHASE (RESULTS AND DISCUSSIONS)

In diagnostic phase the average illuminance, daylight factor, and window-to-floor ratio data for all spaces were compared and analyzed. Other measures were considered to insure controlling internal reflections across the spaces sample as the correlation between the window/floor ratio and the average illuminance. Also, a comparison between the measured illuminance and the international standards for assumed task conducted in spaces. Finally, a cultural preferences discussion and conclusion summarizes the findings.

### Results of the comparative analysis of all spaces

All measurements and calculations are compiled in table 3. The required measures for comparison: Average illuminance, daylight factor, and window to floor ratio.

Space serial No.	Place	Outdoor Illuminance (lx)	Avg. Illuminance (lx)	Daylight Factor (DF)	Windows Area (sq. m.)	Floor Area (sq. m.)	Windows to Floor Ratio (%)
1	Qurayat Fort (Portuguese)	13550	112	0.8	$0.73 \times 5 = 3.65$	26	15
2	Barka Fort (Portuguese)	17400	148	0.9	$0.57 \times 5 = 2.84$	20	14
3	Rustaq Fort (1) (Omani)	14350	361	2.5	$1.57 \times 7 = 11$	44.7	24
4	Rustaq Fort (2) (Omani)	13840	501	3.6	$(0.76 \times 2) + 0.2 + 2.47 = 4.19$	14.31	29
5	Nakhal Fort (Omani)	17000	453		$0.875 \times 10 = 8.75$	31.36	28

Table 3: Data Comparison of all selected spaces

The average illuminance varied through the five selected spaces (Figure 8) two spaces have relatively low illuminance level Qurayat and Barka forts 112 and 148 lx respectively. While the other three spaces in the other two forts have relatively high average illuminance levels: 361 and 501 lx in Rustaq and 453lx in Nakhl forts. Those variations make significant differences when compared to the illumination standards as will be analyzed later in this chapter.

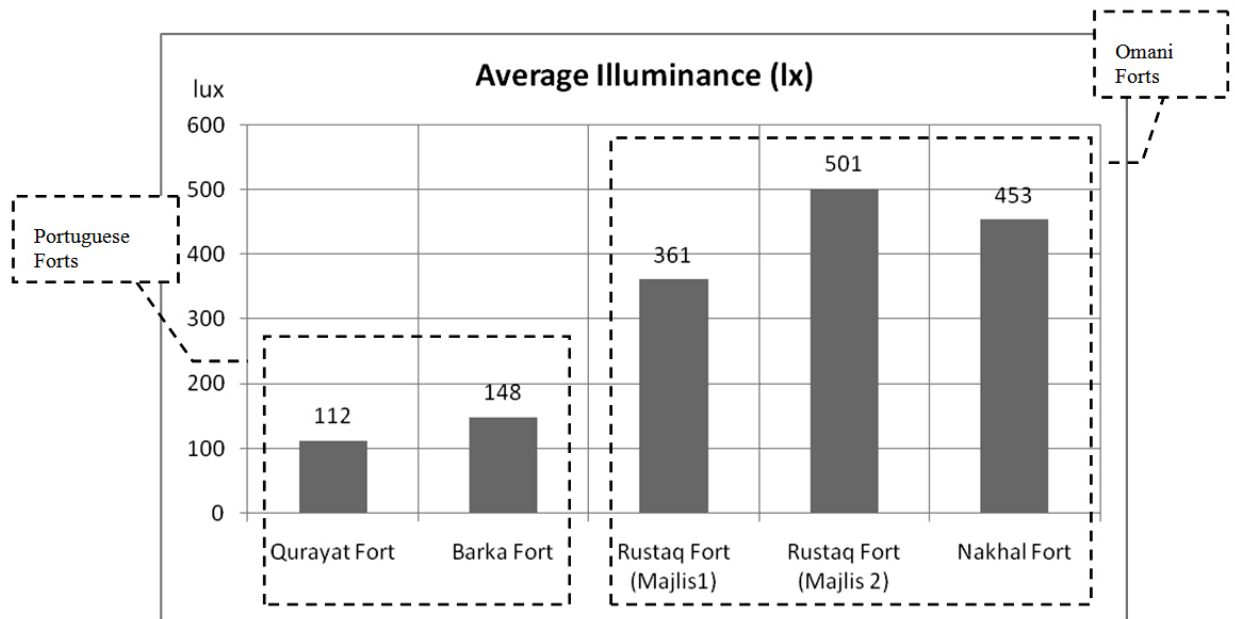


Figure 8: Measured average illuminance of all spaces (by author)

The daylight factor is evidently associated with the illuminance levels in the space, thus a more or less similar pattern can be observed in figure 9. The daylight factor is low in the same two spaces in Qurayat and Rustaq forts representing the low illuminance levels in those spaces. High daylight factor values are calculated for the other three spaces in Rustaq and Nakhl forts.

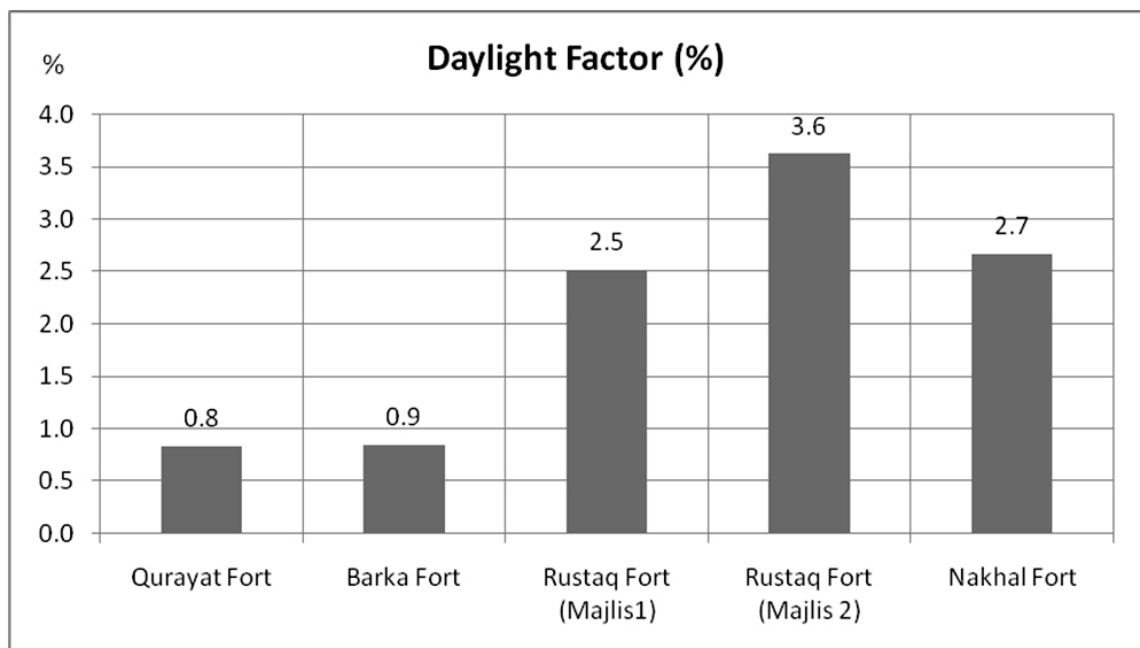


Figure 9: Daylight Factor comparison of all spaces (by author)

Window to floor ratio is an important measure that form a valid indicator of the daylight behavior inside the measured spaces (Figure 10). Undoubtedly, the window to floor ratio would represent the same tendency indicated by the previously mentioned measures: Average illuminance and daylight factor.

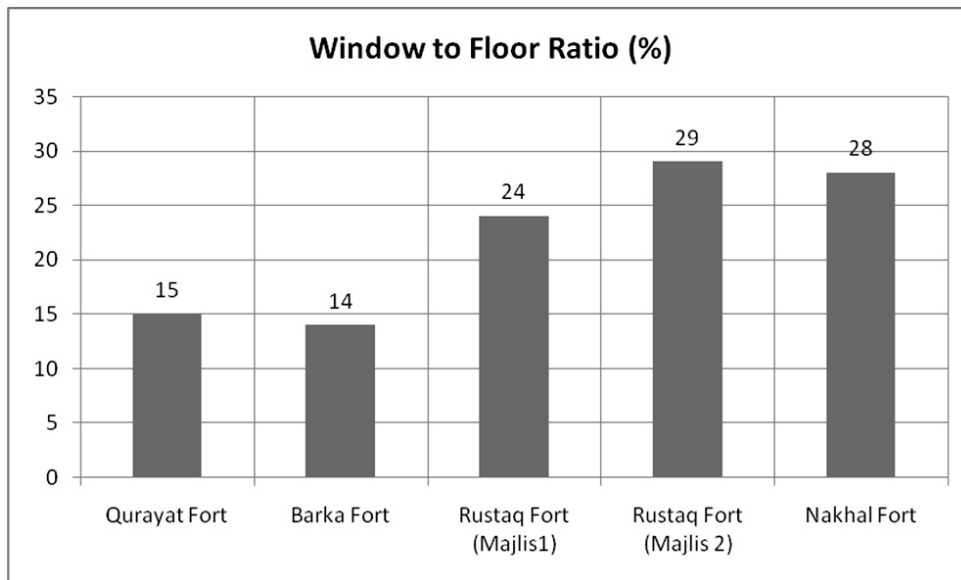


Figure 10: Window to Floor Ratio Comparison of all spaces (by author)

Furthermore, a comparison between window to floor ratio and the associated average illuminance for all spaces was illustrated in Figure 11. Such comparison will assure that the internal reflections, more or less, have the same impact on the average illuminance inside the space. By analyzing the graph, a linear correlation is noticed. This collinear relation suggests that the internal surface reflections of the measured spaces have similar attributes regarding surface luminance. Therefore, the comparison of average illuminance among the selected spaces is valid and the internal reflections are controlled as a factor and its contribution to the lit space do not affect the illuminance level differentiation in the spaces.

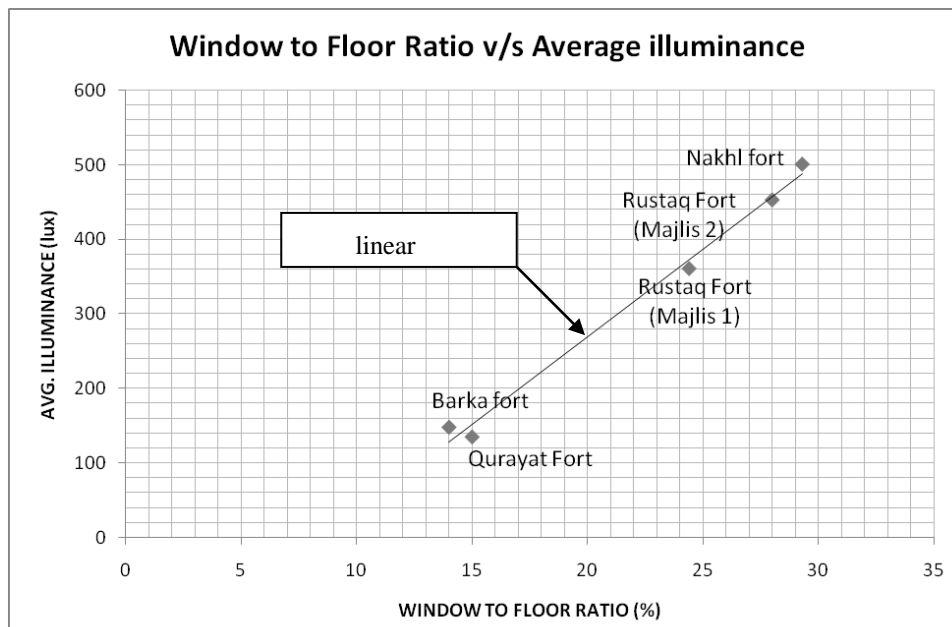


Figure 11: Window to Floor Ratio against illuminance levels for all spaces (regression analysis by author)

**Comparison of all collected data to the Illuminance levels standards (adopted by IESNA)**

Considering the average illuminance level of 300 lx which is suitable for reading and writing, high contrast and large size task (IESNA handbook 2000). Applying such average on the compared illuminance levels in all spaces (Figure 12), evidently there are two spaces fall below the minimum required illuminance level (112 lx and 148 Qurayat and Barka forts respectively). That illuminance levels are even lower that the minimum of 200 lx. The other 3 spaces in Rustaq and Nakhl forts are significantly higher than 300 lx. A larger sample of spaces is definitely would be better to have a solid statistical testing for such results. Those spaces are considered to the study in hand as they give obvious indicators regarding discrepancy in daylight illuminance levels in spaces were built in the same climatic area and in the same era by different inhabitants.

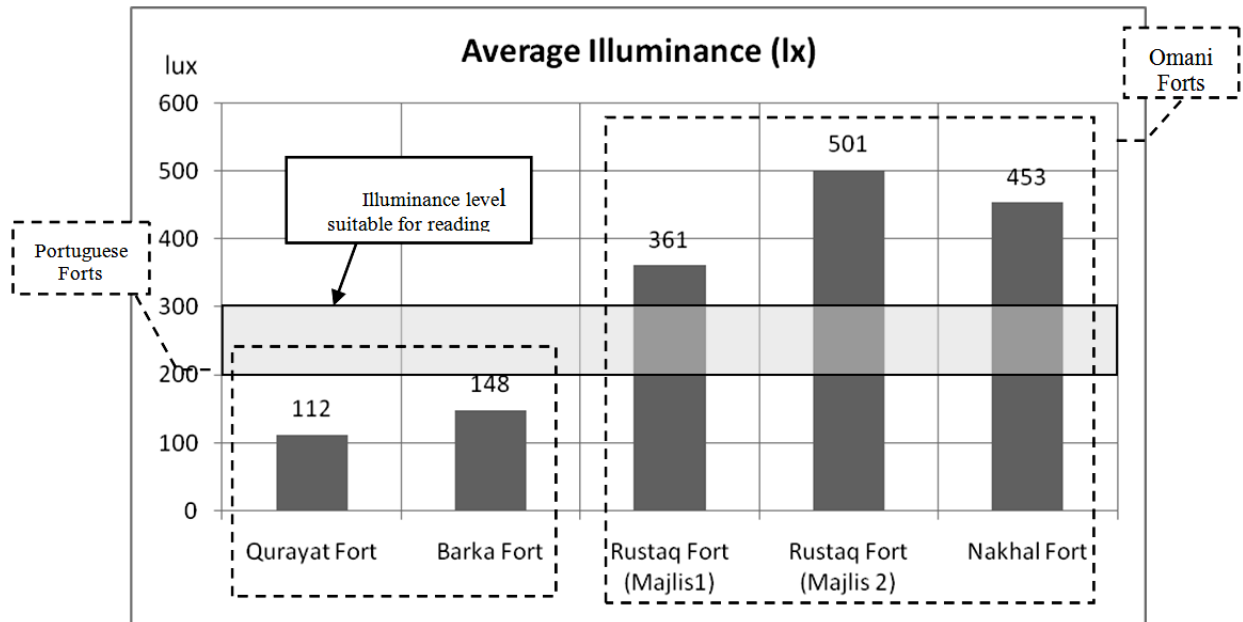


Figure 12: Comparing the average illuminance of the spaces to the standard range adopted by IESNA (graph by author)

## RESULTS AND DISCUSSIONS

### *Cross-Cultural difference in illuminance level preferences*

One clear factor might explain such discrepancy, those spaces (in forts) were built and inhabited by two different inhabitants come from two different cultural and environmental backgrounds; Omanis and Portuguese).

As for the spaces in Rustaq and Nakhl forts (Omani origin buildings); the illuminance levels are approximately between 360 and 500 lx. Those readings are higher than the recommended illuminance levels required for the task that is usually takes place in such spaces. Mentioned high illuminance level can be understood as preferences for illuminance levels are generally higher than the recommended levels (Belcher 1985); this is true regardless of culture. Therefore, the low illuminance level in Qurayat and Barka forts spaces (Portuguese origins buildings) is questionable.

Knowing that Qurayat and Barka forts were built and used by Portuguese would explain the low illuminance level measured in these two spaces. An obvious relation between lighting preference and cultural background of the users is a satisfactory explanation. The user preference of light level within a space depends on the user's geographic location (latitude). Omani inhabitants are ecologically adapted to the life in climate with extremely bright sunlight over long hours per day across the year; they have good black/white vision which helps them to survive in such climate. Portuguese who come from a different environment were not used to such bright daylight. Biologically speaking, Europeans (live in higher latitude – Figure 1) have highly developed color vision (regarding the daylight distribution in their areas) rather than black/white vision (Pettersson 1982).

## CONCLUSION

The research in hand achieved many findings, some are expected and other findings were surprising. Conclusions about the lighting characteristics of the selected spaces were derived out of the previously stated results and discussions in the investigative phase.

The main hypothesis that relates the design of the openings of the old forts to the functional needs was confirmed in two forts in interior regions, Rustaq and Nakhl. The measured illuminance levels found to be above the international standards regarding the task in hand, common writing and reading. That is confirmed from prior research that users usually tend to ask for more than the standards regarding their needs of a specific task.

The other two spaces in Qurayat and Barka forts that lie on the coastal area found to have significantly low illuminance levels, much lower than the standards. That interesting finding led to investigation regarding those forts origins. It has been found that Qurayat and Barka (as many coastal forts) were built and inhabited by Portuguese, whereas the forts in the interior regions were built and inhabited by Omani citizens.

This study indicated that lighting preference is not universal. People from different geographical locations are adapted to certain illuminance levels, so the standards cannot be generalized for the entire world population.

Therefore, standards that effectively address the diversity of user needs in our globally connected society should be developed and employed. One convenient way of addressing this situation is by dividing the world into similar climatic zones and standards should be established for these zones according to user preferences.

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