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Application of Geospatial Information System for the Study of Illuminance in Carpet Weaving Workshops in Bokan, Iran

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A B S T R A C T

Background: Carpet weaving is an occupation that requires sufficient and appropriate lighting. The lighting in carpet weaving workshops affects the productivity and the physical and mental health of workers. Therefore, the evaluation of the illumination and the identification of work stations requiring lighting modifications will be helpful in promotion of the health and safety of workers in carpet weaving workshops.
Methods: This study was carried out for the evaluation of illumination on the basis of Geospatial Information System (GIS) technology in two carpet weaving workshops of Bokan city. As per the norms of Illumination Engineering Society, the sensors of the photometer Testo 545 were placed at lowest and highest of 35 and 163 cm in workshop I, and at 40 and 245 cm in workshop II, which correspond to the lowest and highest work surfaces in the respective workshops. Total, natural, and artificial illuminance was measured in the center of each measurement station using the photometer, and data was analyzed using the Arc GIS software. The maximum and minimum illuminances as well as isolux curves were obtained for each workshop.
Results: The illuminance in workshops I and II were found to be lower and higher, respectively, than 200 lux, which is considered the standard for carpet weaving workshops. Thus, improving the artificial lighting system or redesigning it is essential for ensuring that the standard conditions of illuminance (200–300 lux) are provided.
Discussion: This study showed that the application of GIS technology renders the assessment of illumination in carpet weaving workshops possible. This assessment method could also prove useful for determining the exact stations in the carpet weaving workshops that need modifications, thereby leading to cost reduction.

1. Introduction

Vision is a vital sense in humans, who chiefly acquire knowledge of their surroundings through sight. Sufficient light is essential for good vision, and poor lighting potentially leads to a variety of disorders such as eyestrain, ocular headache, defective vision, physical fatigue, and mental complications [1]. Furthermore, low luminance contributes to accidents such as falling and human errors. The more delicate and accurate the employment task, the more attention needs to be paid to lighting in the

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work place. Thus, appropriate luminance aims to facilitate a high standard of visual skill, and is achieved through an accurate programmed system that considers all the factors related to work place illumination. Carpet weaving, regarded as a delicate job, has a higher light requirement compared to other ordinary occupations, as focus on the weaving point demands sufficient light [2].

Carpet weaving is a major industry in Iran, and therefore, knowledge of monitoring and operating lighting systems is essential in carpet weaving workshops [3]. Currently, lighting systems can be monitored through the use of modern technology such as Geospatial Information System (GIS), which is used for saving, storage, management, and analysis of spatial data; this data is processed using computer software, which investigates different situations and makes new predictions.

Various studies have shown the efficacy of GIS in other fields [4-6]; hence, this technology could also be employed for assessing lighting in carpet weaving workshops. The present study was designed to investigate the application of GIS-based software for monitoring natural, artificial, and total illumination in a carpet weaving workshop with 21 weavers in Bokan, Iran. Figure 1 shows a carpet loom in this workshop.

Fig.1: A carpet looms in a carpet weaving workshop in Bokan.

2. Materials and Methods

Illuminance was measured in two carpet weaving workshops in Bokan, a city located in Kordestan Province, Iran.

In each workshop, the floor was divided into squares of 3 × 3 m, and the center of each square was marked as a measurement station, as recommended by IESNA (Illumination Engineering Society of North America) [7]. The positions of stations, windows, doors, and carpet looms in workshop II are shown (Fig. 2).

Fig. 2: Positions of measurement stations (1–10), carpet looms, windows, and doors in workshop II.

Due to the presence of more than two carpet looms in the workshops, different work surfaces were encountered. Therefore, measurements were made in the lowest and highest carpet weaving work surfaces, which corresponded to 35 and 163 cm, respectively, for workshop I, and 40 and 245 cm, respectively, for workshop II. After the measurement stations were determined, sensors for the Testo 545 photometer, manufactured by Testo Company, were placed in the highest and lowest work surfaces, and the illuminance in each station was measured in lux units. Given the aims of this research study, the measurement of total illuminance (both natural and artificial), and the choice of appropriate measurement times were of great importance. Unfortunately, entrance to the workshops was limited to the quitting time of weavers. Measurements in workshop I were carried out on 15/5/2011 at 19:06 hours, and in workshop II, on

16/25/2011 at 11:10 hours, both under conditions of completely clear skies. During day time, all the windows and doors of the workshops were kept open. The Arc GIS software, version 10 was utilized for plotting isolux curves and determining variations in illuminance. For this purpose, the plan of the workshops was drawn, and illuminance in the measurement stations was determined using the software. Subsequently, the measured values of illuminance in each station were entered into the software, and isolux curves were plotted.

3. Results

Illuminance measurements were made once each in the lowest and highest work surfaces in both workshops. In workshop I, 16 stations were determined by dividing the floor into squares of 3 × 3 m. The highest and lowest work surfaces of carpet weavers measured 163 and 35 cm, respectively. The illuminance measurements in all stations of workshop I are shown in Table 1.

Figure 3 shows software-generated isolux curves using illumination data for the highest work surface in workshop I. Figure 3 clearly shows that the illumination in the highest work surface of workshop I was lower than 100 lux, except for stations 8 and 10. The isolux curves using illumination data for the lowest work surface in workshop I are depicted in Figure 4. The highest illuminance (172 lux) was found at the entrance, while the lowest value encountered was 26 lux. Ten stations were determined in workshop II due to its smaller size. The highest and lowest work surfaces of carpet weavers measured 245 cm and 40 cm, respectively. Illuminance measurements are shown in Table 2.

Table 1: Illumination measurement data in the highest and the lowest work surfaces in workshop I.

Station No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
In the Highest Work Surface	92	86	45	68	41	82	42	114	51	176	37	87	33	63	32	32
In the Lowest Work Surface	172	88	42	52	30	53	35	81	40	125	31	75	33	53	36	26

Table 2: Illumination measurement data (lux) in the highest and the lowest work surfaces in workshop II.

Station No.	1	2	3	4	5	6	7	8	9	10
in the Highest Work Surface	352	1329	312	458	270	615	367	1580	486	2230
In the Lowest Work Surface	834	723	452	1926	339	236	732	322	196	276

Figure 5 shows the isolux curves using illumination data for the highest work surface in workshop II. The data shows that illuminance in all stations of workshop II was higher than 300 lux, with the exception of station 5. The isolux curve using illumination data for the lowest work surface in workshop II is depicted in Figure 6. The highest and lowest illuminance were found to be 1926 and 196 lux, respectively. As depicted in Figure 6, the illuminance in all stations in the lowest work surface of workshop II was higher than 300 lux, with the exception of stations 9 and 10. Table 3 shows the maximum and minimum illuminance measured in the stations of both workshops.

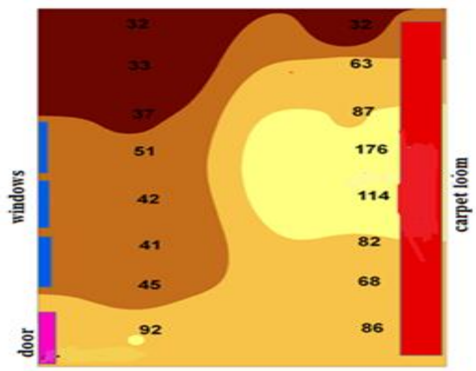

Fig. 3: Isolux curve for total illuminance (natural and artificial) measured in each station in the highest work surface (163 cm) of workshop I. The numbers represent illuminance (lux).

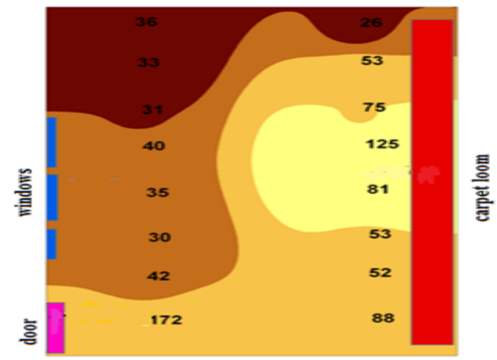

Fig. 4: Isolux curve for total illuminance (natural and artificial) measured in each station in the lowest work surface (35 cm) of workshop I. The numbers represent illuminance (lux).

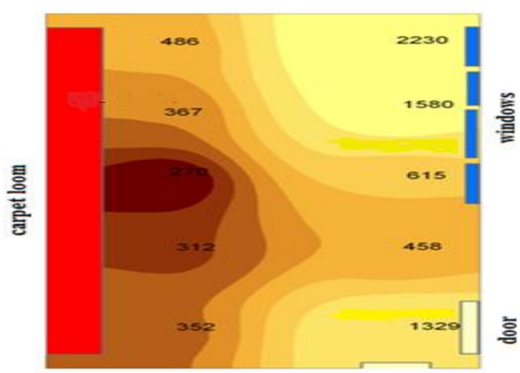

Fig. 5: Isolux curves for total illuminance (natural and artificial) measured in each station in the highest work surface (245 cm) of workshop II. The numbers represent illuminance (lux).

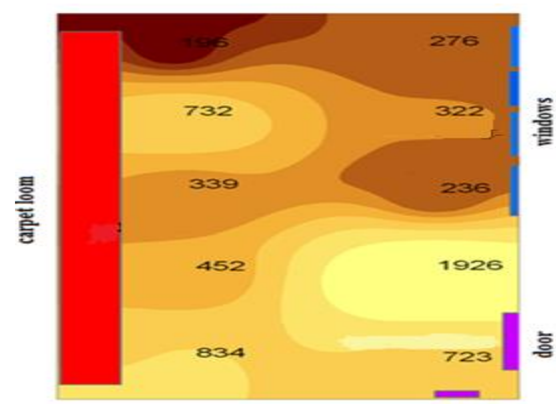

Fig. 6: Isolux curve for total illuminance (natural and artificial) measured in each station in the lowest work surface (40 cm) of workshop II. The numbers represent illuminance (lux).

Table 3: the maximum and minimum values of illuminance (lux) in the highest and lowest work surface for both workshops.

workshop	In the Highest Work Surface		In the Lowest Work Surface	
	Min	Max	Min	Max
I	32	176	26	172
II	270	2230	196	1926

4. Discussion and conclusion

Light is a physical workplace parameter, and appropriate lighting system has been shown to play a vital role in the maintenance of healthy vision. In addition, appropriate lighting improves work conditions, health, and safety factors in the work place, promotes work quality, and also prevents job-related accidents [10]. A minimum threshold of illumination is necessary for improving work conditions and ensuring the psychological welfare and adjustment of workers [1], because illuminance of less than 30 lux causes eye strain. A number of oculists believe that near-sightedness results from lack of good light. Therefore, appropriate lighting should be emphasized for the prevention of eye strain, which is typically associated with tiredness and general fatigue [1]. Carpet weaving is an occupation that requires sufficient and appropriate lighting. In addition, weavers spend long periods of time weaving carpets in the workshops. Thus, appropriate light distribution in the workshops greatly helps the avoidance of eye strain. Studies conducted to date have focused mainly on manufacturing industries. In the absence of previous research on illumination in carpet weaving workshops using GIS technology, the present study graphically demonstrates variation in illumination through the use of isolux curves using GIS-based software. Studies on lighting have thus far focused on major industries, while minor workshops have been neglected. For instance, Ranjbaran conducted a study with the aim of determining the illuminance of carpet looms and carpet weaving workshops, and comparing them with available standards from 25 workshops [8]. The maximum and minimum illuminance was found to be 327 and 7 lux, respectively, with mean values of 10–261 lux and standard deviation of 24–90.16 lux; these results revealed below-standard illuminance in all the workshops, as per the standard designated by IES[1] (200–300 lux). In another study carried out by Madjidi et al. in Zanjan, illuminance in libraries with non-geometric shapes was evaluated based on IESNA guidelines [9]; natural, artificial, and total illuminance in each station was measured through photometer sensors placed at a height of 75 cm above the floors of non-geometric libraries in Zanjan. GIS software (ArcView version 3.2) was employed for determining the percentage of illuminated surface area and the isolux curves. The study revealed insufficient illumination in the libraries investigated, because natural, artificial, and total illuminance in 51%, 99%, and 80% of the libraries were lower than 300 lux (the IES standard). The application of GIS technology for the evaluation of illuminance and plotting of isolux curves for locations with non-geometric shapes has also been carried out in another study [5]. The main objective of the present study was the evaluation of illuminance at heights of 35 cm and 163 cm in workshop I, and 40 cm and 245 cm in workshop II, using GIS technology through ArcMap software. The results showed that illuminance in workshops varied between 26 and 2230 lux; specifically, in workshop I, the illuminance in the lowest work surface varied between 26 and 172 lux, and in the highest work surface, between 32 and 176 lux. Thus, given the standard recommended values of 200–300 lux for carpet weaving workshops, less than standard illumination was observed in the present study, at least with respect to workshop I. In workshop II, the minimum and maximum illuminance in the lowest work surface were found to be 196 and 1926 lux, respectively, and in the highest work surface, 270 and 2230

[1] - Illumination Engineering Society

lux, respectively. Thus, the analysis carried out in the present study indicates a requirement for redesigning and improving artificial illuminance in carpet weaving workshops. The illuminance of the measured work surfaces in carpet weaving workshop I was found to be below standard, thereby indicating a necessity for basic improvements in the lighting system. Increased height from the floor increased the illuminance of the work surface, with the exception of stations 1, 2 (both stations were beside the entrance), and 15. On the other hand, the illuminance in workshop II was above standard. The highest work surface in this workshop had much greater illuminance than the standard (200–300 lux) in all stations except station 5. In the lowest work surface in workshop II, the maximum and minimum illuminance was measured as 1926 and 196 lux, respectively.

Station 9 in this workshop was below standard, stations 6 and 10 were within the standard range, and the other stations were above standard. These uncoordinated values of illuminance expose the poor lighting system, and consequently, poor distribution of light. A cursory glance of Table 1 shows that while certain stations received poor light, others received excessive light. A major contributing factor to the lack of good lighting system in workshop I was the small number of light bulbs and their inappropriate choice, given that 40-W filament-type light bulbs were used in the workshop. Moreover, defective light bulbs had not been replaced with new ones. Other causes of poor lighting in workshop I include bad setting of light bulbs and their inappropriate distances from the weavers and carpet looms. In workshop II, which had formerly been a livestock farm, the natural illuminance was above standard owing to wrong design of lighting system and inappropriately positioned windows. These results show that inappropriate illuminance in the workshops were the result of poor placing of light bulbs in the field of vision, which causes eyestrain. In addition, insufficient number or wrong choice of light bulbs, inappropriately positioned windows, wrong positioning of the carpet loom, inappropriate height of light bulbs from work surface, and inappropriate painting of workshop surfaces are the other causes of eyestrain.

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