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Evaluation of Illumination Desirability in Bolt Manufacturing Industry by GIS Software in 2014

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ABSTRACT

The sense of sight is the most important human sense by which the maximum information may be obtained from the surrounding environment. Therefore, there should be adequate light. Thus the present study evaluates the illumination intensity of one of the bolt manufacturing industries to use its results for corrective measures. This study is a cross - sectional study that is conducted in one of the bolt manufacturing industries in Yazd City. Measurement of natural and artificial light is done in 2014 in a cloudy day in December by network method in manufacturing, molding, threading and pulling facilities by lux meter model TES 1330A. Then using this information the illumination map of the isolux of the manufacturing hall is mapped by ArcView software. Since most working hours of workers is associated with systems in fixed points, the local illumination in the operation area is measured. The highest measured points is associated with manufacturing hall (54 points) and the least points is associated with the molding hall the (14 points). The results showed that the minimum and maximum combined illumination intensities are associated with molding (153.92 ± 106.91) and manufacturing (88.39 ± 325. 11) halls. Natural illumination level is calculated in terms of the halls that the minimum illumination is associated with molding hall (114.33 ± 80.50) and the maximum illumination is associated with manufacturing hall(66.25 ± 253.12). In manufacturing hall most points are in the range of above 300L. The percent of light bulbs in the manufacturing halls is 70%. Some bolt manufacturing halls had good combined illumination but they lacked proper natural illumination. Thus by necessary interventions such as replacement of the broken lamps, correct alignment and cleaning the lamps it is possible to achieve an optimal level of illumination.

Key words: *illumination intensity, bolt manufacturing, geographic information systems*

INTRODUCTION

Illumination is one of the most important physical issues of work place. Light is not only used to see objects and get things done but also it is used as the main factor to create a pleasant working environment. Today, the issue of

providing illumination for workshops and industrial environments has a special significance because the workers and employees spend most of their time in places that are lit with artificial light during the day. If the adequate illumination is not considered in designing and maintenance of the illumination systems, insufficient and poor illumination can cause eyestrain, headache, visual impairment and failure to correctly identify objects and colors, glare and even cause accidents. (1) The sense of sight is considered the most important and most vital human sense. Using the sense of sight human being obtains most information from the environment. Good eyesight needs sufficient illumination. Lack or excess of light can cause various problems, such as eyestrain, headaches, impaired vision, glare, fatigue, and psychological effects. Also the amount of illumination is effective in the incidence of accidents such as falling objects of people and human errors (2). According to studies conducted by the Illuminating Engineering Society (IES: Illuminating Engineering Society) it is observed that when the illumination level increases from 65 to 170 lux, the incident repeatability coefficient is reduced by 20%. Illumination such as safety at work factor in an industrial environment is an important factor in creating a normal working condition and provides the best type of vision in workplace (3). In a study conducted on the carpet weaver children in India, Nepal and the Pakistan the results showed that improving workplace safety and health particularly desirable illumination in carpet weaving workshops plays an important role in the health of carpet weavers. That is because good illumination is essential to prevent fatigue and insufficient light leads to awkward postures at work and the incidence of musculoskeletal disorders (4). Proper daylight can be divided into three main areas: a) illumination between 100 and 500 lux both as the only source of illumination or in combination with artificial illumination which is considered as efficient illumination and is suitable for some jobs, b) illumination between 500 and 2000 lux which is usually considered as the optimal or at least tolerable illumination for many jobs and c) more than 2000 lux illumination which is unacceptable and causes glare and workers' discomfort. (5) Although the use of daylight has great economic benefits, a great energy is spent on illumination residential and commercial spaces and the elimination of the heat from the illumination systems due to its insufficiency (6). So illumination modification economic issues in industries are expensive but spending money in this regard is necessary and providing optimum illumination requires addressing both health and economic aspects. The health aspect is based on special human characteristics such as vision, eye sensitivity to detect colors, vision's speed of understanding, illumination and vision clarity. The existence of a reasonable illumination in industrial buildings requires a general illumination in all surrounding space, which increases safety in the traffic of cars and pedestrians' (7). The results of Vihma and Nurminen showed that improved illumination in small industries can reduce workload and increase efficiency (8). Illumination is one of the modifiable physical factors and plays an important role in creating safe and healthy environment and increasing economic indicators of each country and increases work efficiency (9). The use of new technologies such as geographic information systems (GIS) can be used to assess illumination. The system is used to store, maintain, manage and analyze the data with spatial and descriptive dependence and by processing the software data analyzes different states and provides good results (10). So it seems that this knowledge can be used to measure the illumination industry. Therefore based on the limited studies done in this area and the working process of bolt manufacturing industry in which illumination has specific importance, it is decided to perform illumination analysis and desirability in different halls of bolt manufacturing industry.

MATERIALS AND METHODS

The present cross-sectional research is a descriptive - analytical study conducted in one of bolt manufacturing industries of Yazd City. In this industry general and natural illumination values are measured by network method in its halls including manufacturing, molding, threading and pulling and the local illumination is assessed. The measurement is performed in 2014 on a cloudy day between the hours of 12:30 to 14:30 in December. The values of illumination intensity is measured and calculated by the Illuminating Engineering Society of America (1). After determining the size and dimensions of the halls, each hall is divided into 3 × 3 m dimensions and the illumination of the center of these squares is measured at the height of 30 inches (76 cm), recommended by (IENSA: Illuminating Engineering Society of North America) by lux meter model TES 1330A to plot the Isolux geographic illumination map. The combined illumination (artificial and natural) of the hall is measured is measured after ensuring that the lamps are on. It should be noted that due to the company's use of gas lamps to light up the lamps there is 20 minute head start to maximize illumination. Then the lights are turned off and natural illumination is measured. Since the company under study id single shift, (morning shift) it was not possible to measure the artificial illumination. Since most working hours of workers with devises were at fixed points, the local illumination was also measured in the operating zone of the machines as well. After entering the data in SPSS software and data analysis, the maximum, minimum and mean and standard deviation from illumination intensity standard values were calculated. Also using the results and interpolating the measured values by network method using the Arc View software the Isolux curves

were plotted for all halls. ArcView software is one of the GIS based designed applications that provides Isolux curves by network measurements and interpolation of information layers. The mentioned application is presented by environmental systems Research Institute (ESRI) and it is a strong positioning system (11). Also the position of the devises, lamps, the lamps' being on or off and the location of doors and windows were determined on the map.

RESULTS

Tables 1 and 2 represent combined illumination (artificial and natural together) and natural illumination intensities in terms of the halls in bolt manufacturing industry in December 2014. The number of workstations in combined illumination (artificial and natural together) and natural illumination in different halls is presented in tables. The maximum measured points were associated with the manufacturing hall (54 points) and the minimum measured points were associated with molding hall (14 points). In Tables of general illumination the mean, standard deviation, minimum and maximum illuminations are presented. According to the results the minimum and maximum combined illumination intensities are associated with molding (153.92 ± 106.91) and manufacturing (88.39 ± 325.11) halls. Also the minimum and maximum combined illuminations are associated with molding hall (63 lux) and pulling hall (930 lux). Table 2 is also associated with the natural light in terms of halls in December in bolt manufacturing industry. In this table the minimum illumination is associated with molding hall (114.33 ± 80.50) and the maximum illumination is associated with manufacturing hall (66.25 ± 253.12).

Table 1- The combined illumination intensity in terms of hall in lux in December 2014

Hall name	Number of station	Illuminating (Lux)		
		Mean ±SD	Minimum	Maximum
manufacturing	54	325.11 ±88.39	120	487
Pulling	35	210.11 ±270.63	72	930
Molding	14	106.91 ±153.92	63	460
Threading	19	122.80 ±55.24	210	417

Table 2- The natural illumination intensity in terms of hall in lux in December 2014

Hall name	Number of station	Illuminating (Lux)		
		Mean ±SD	Minimum	Maximum
manufacturing	54	253.12 ±66.25	108	369
Pulling	35	169.40 ±207.25	72	734
Molding	14	80.50 ±114.33	43	346
Threading	19	99.02 ±56.22	176	397

Table 3 shows the mean local illumination intensity at workstation in each hall. According to the table the maximum illumination has been associated with manufacturing hall (22.70). The proposed illumination intensity based on IES standard is 300 lux (3).

Table 3- Average local illumination in terms of halls at the main workstations

Hall name	Recommended Illuminating (lux)	Measured Illuminating (Mean ±SD)
manufacturing	300	364.51 ±22.70
Pulling	300	274.54 ±21.02
Molding	300	324.43 ±25.74
Threading	300	286.38 ±12.64

Figure 1 indicates the Isolux curves, the position of lamps and machines and the level of combined lighting at three ranges (<200 lux, 200-300 lux and> 300). According to the figure it is observed that most points are in the third area which is more than 300 lux. The percentage of broken and working lamps in each hall is calculated. The percentage of light bulbs in the threading, molding, manufacturing and pulling salons are 100, 60, 70 and 65% respectively.

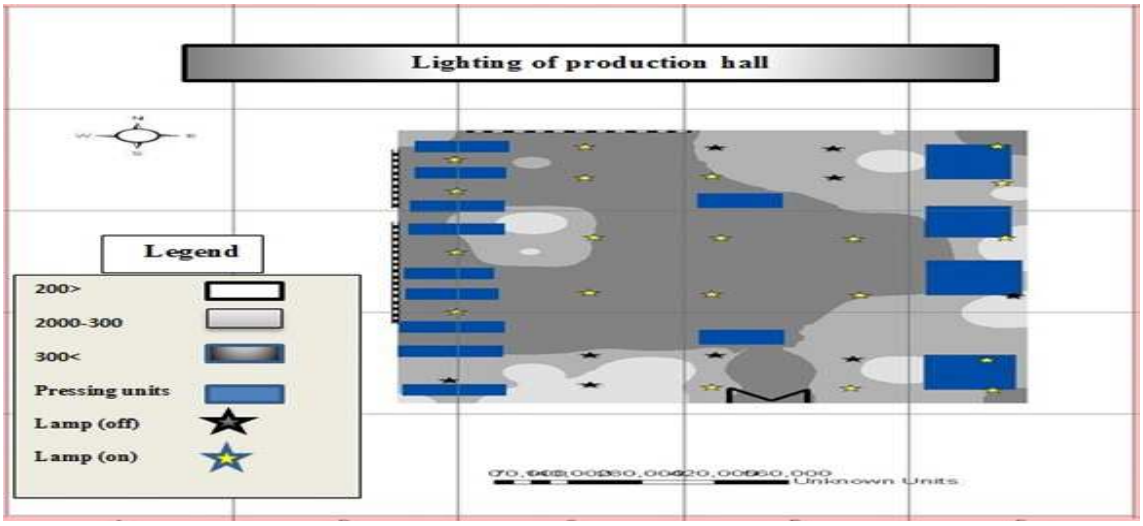

Figure 1: The illumination of the manufacturing (production) hall using Arc View software in the ranges below 200, 200-300 and over 300 lux.

DISCUSSION

Due to advances in science and technology in the contemporary era, industrialization in society, and consequently spending a significant part of the day in indoor workplaces using proper illumination in industries is of great importance. The results of the present study showed that the level of illumination in all halls _ except the combined manufacturing illumination_ is lower than the standard level and it is defective. As a result, interventions must be done to eliminate illumination system flaws. In Kakouei et al. the results showed that in the plaque, rotative, linotron typography, engraving, rotative offset and hand-binding illumination has low standard (200 lux) and in linotron forming, sheet offset, binding journals, lead typography, lead typesetting correction and linotron punching the illumination level is of higher standard (300 lux) (9). In Ranjbarian that evaluated the illumination intensity of carpet weaving workshops and the sight of workers in Tekab, the results showed that 48.6% of the weavers had eyesight impairment. Lighting intensity (82.4%) and illumination intensity (91.9%) of the workshops were less than the standard level (12). In another study conducted by Kakouei and Poornajaf in electrical industries, it was concluded that among all posts 19.8 % had sufficient illumination and 46.1% had moderate illumination. 29.7% had inadequate illumination (13). Also in the study conducted by Soleymanloo in Tehran industrial towns, the sufficient daylight illumination is about 56% and the useful daylight illumination is between 56-100% for a hypothetical workshop (14). In a study conducted by Lamber to evaluate the workstations the illumination within the range of 500-400 lux is acceptable for the operators (15). According to the results of Isolux curves in the manufacturing halls the amount of illumination in the hall is more than 300 lux which is adequate the reasons of which is les broken lamps than molding and pulling salons. Also the color of the surfaces in the mentioned hall is desirable and the windows had higher surfaces area compared to other halls. Also the level of illumination at the main workstations was lower than the standard level except the manufacturing and molding halls.

CONCLUSION

The results of this study showed that in most halls illumination is defective and substandard. Industrial occupations include various types of visual tasks; therefore illumination in the industries in addition to create a pleasant environment should provide optimum illumination conditions such as sufficient lighting and contrast. Therefore, performing ergonomic interventions including cleaning the lights, changing the broken lamps in all halls and the use of bright colors the on the ceiling and walls especially in the halls where lighting is below the standard is necessary. Additionally the number and arrangement of the lightings should be based on lighting design calculations.

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