EFFECTS OF EXISTING LIGHTING CONTROL SYSTEMS ON PEOPLE

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ABSTRACT

In this study, an inquiry and an experimental study are made with the participation of people who work in an office. The aim of these studies is to search the effects of the existing lighting control systems on people, which adjust the artificial illumination level of the office continuously to be constant on working plane according to daylight level.
In conclusion of the inquiry and experimental studies, it is understood that requirements of persons differ from each other to a great extent. Under this condition, it is obvious and very clear that existing lighting control systems programmed to provide only single constant illumination level throughout year can not meet the visual and comfort requirements of persons.

1. INTRODUCTION

With the lighting control systems that can adjusted artificial illumination level continuously depending on the daylight level one can save energy up to 50% [1]. The existing lighting control systems that are being used by nowadays adjust the artificial illumination level according to daylight until the illumination level on the working plane comes to a constant pre-set value. The only purpose of these systems is to save energy by reducing the energy consumption. The personal wishes of the users in illumination subject are never paid any attention.
On the other hand, it has been known that a good quality and a suitable lighting according to the users wishes increases the motivation and the productivity of the workers [2]. Especially, increasing the productivity of high-salary paid skilled staff employees means a great saving. For this reason the saving that is provided by lighting control systems is not to be thought only a decrease in energy consumption, but also an increase in the productivity of workers. The first purpose of lighting control systems is to increase the performance of workers by having them to feel good about themselves, the second purpose is to decrease the electrical energy consumption. In summary, the optimum solution must be searched where a maximum productivity provided with minimum energy consumption.
The physiological needs of human being change according to the age, gender, health, and cultural level; and the psychological condition changes according to seasons, time, and some personal factors [3]. Therefore, the lighting control systems, which are realised by determining a constant illumination level can not respond all users' needs. Because of some absences at existing systems a chance of adjusting the illumination level by hand is given to people so that they can adjust the level the way they want. But it is also known that people who work under intensive and hard conditions don't have any time to adjust the illumination level (or simply they forget to do it). Because of that reason, use of remote control systems to achieve a good quality and energy saving optimum lighting solution is not possible [4].
In this study, an inquiry and an experimental study are made with the participation of people who work in an office. The aim of these studies is to search the effects of the existing lighting control systems on people, which adjust the artificial illumination level of the office continuously to be constant on working plane according to daylight level.

2. INQUIRY STUDY

Inquiry study has been conducted with 32 employees working in six office buildings having lighting control systems in Istanbul. People to whom the inquiry study applied are 18 females and 14 males out of which 8 are under 25 years age, 17 are between 25 and 35 years age, and 7 are older than 35 years age. Out of 32 office employees, 2 have been working in similar office ambience less than 6 months, 22 have been working between 6 months and 3 years, and 8 have been working more than 3 years period respectively.

2.1. Results of Inquiry Study

Subjects are asked whether they are satisfied from lighting control depending on daylight level or not, and the following results obtained upon the evaluation of given answers.

- While 28% of female employees are satisfied with lighting control systems, 33% are not satisfied with the existing lighting level, and for the remaining 39% it is not important whether such system exists.
- 29% of male employees are satisfied, 36% is not satisfied, and it does not make any difference for the remaining 35%.

- The 29% of employees who are under 25 years age are satisfied, 29% is not satisfied, and it does not make any difference for 42%.
- The 28% of employees between 25 and 35 years age are satisfied, 39% is not satisfied, and it does not make any difference for 33%.
- The 29% of employees older than 35 years age are satisfied, 29% are not satisfied, and it does not make any difference for 42%.
- The 100% of employees working less than 6 months at an office ambience has expressed to be satisfied from the lighting control systems.
- The 32% of employees whose working periods vary between 6 months and 3 years are satisfied, 36% is not satisfied, and this condition does not make any change for 32%.
- No one has expressed to have been satisfied from automation among employees working more than 3 years under office ambience. The 38% of this group has stated a dissatisfaction from these systems, and 62% has stated that this condition does not make any difference for them.

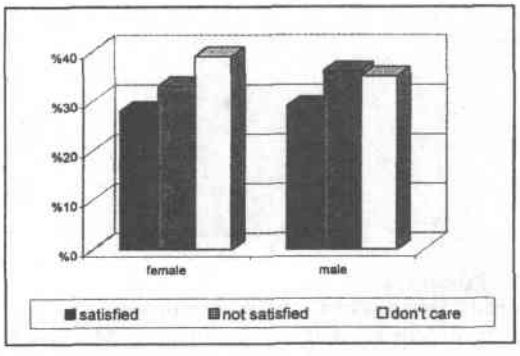

Figure 1. Results of inquiry study according to gender

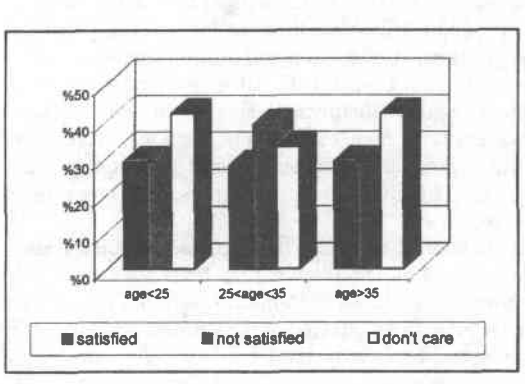

Figure 2. Results of inquiry study according to age

In general, out of total 32 persons participating to the inquiry study, 28% has expressed to be satisfied from the systems, 34% has expressed not to be satisfied from the systems, and 38% has expressed that this condition has not change their working conditions respectively.

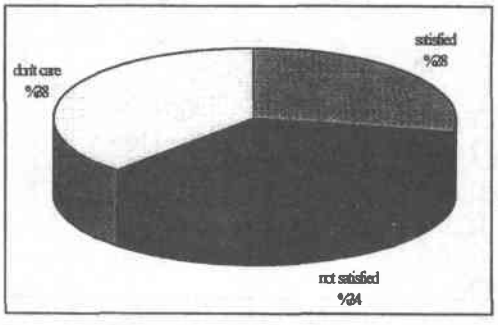

Figure 3. General results of inquiry study

2.2. Discussion of the Inquiry Results

In general, regardless of gender it is understood from the results that approximately equal proportions of subjects questioned are satisfied, not satisfied, and unconcerned from existing systems. In accordance with results of inquiry study, it can be stated that only 28% of employees working under ambience where lighting control systems exist, are satisfied from systems (Figure 3).

It is also observed from results of this inquiry study, that employees who have worked under office ambience without automation previously (ones having more than 3 years working period) have difficulties to get adapted into new systems, and whereas employees who have recently started working have adapted themselves more quickly to lighting control systems.

3. EXPERIMENTAL STUDY

A total of 15 subjects took part in the experiments. Each subject spent on average two hours to make his or her assessments.

3.1. Set-up

An office in dimensions of 3.35m x 6.25m x 3.25m located in third floor of the Electrical and Electronics Faculty of Istanbul Technical University and whose windows are oriented towards north-east direction was arranged as a test office [5]. This project is being supported by TUBITAK (Turkish Research Council), ITU (Istanbul Technical University), Zumtobel and Siemens. Ceiling of office, which is used by real office employees, is in white colour, its walls in grey colour and its floor is in light blue colour respectively. The reflection factors of the room surfaces are: working plane 0.6, walls 0.8, ceiling 0.7 and floor 0.2.

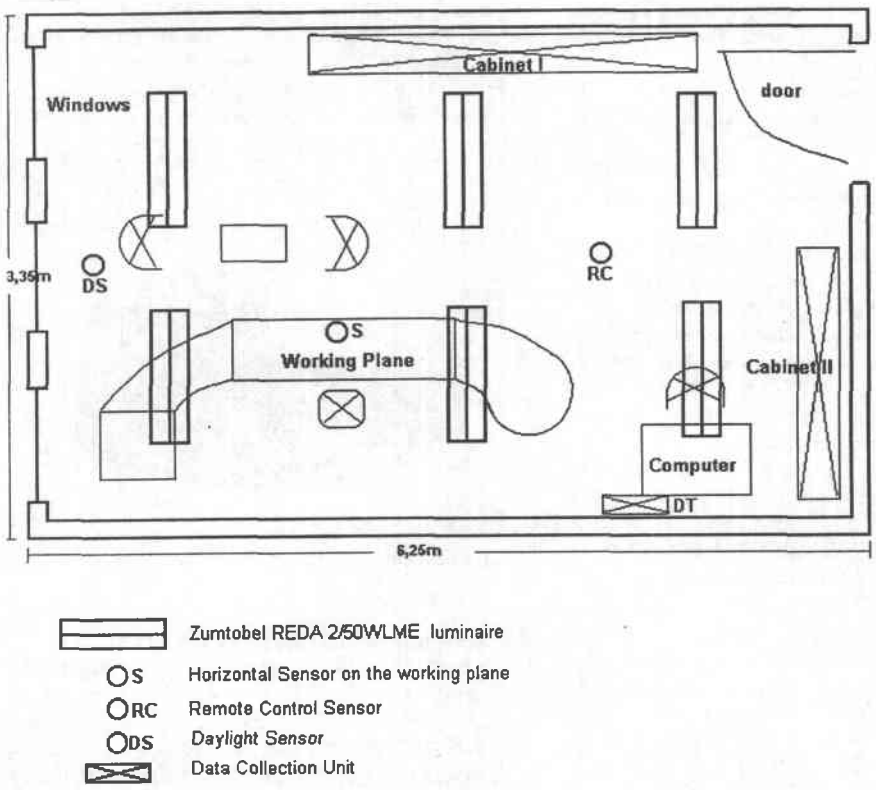

Figure 4. Lay-out test office

Volume was furnished by light grey furniture having high reflection factor in functional manner. The illumination has been established by 6 luminaries with a double parabolic mirror louvre, which has two 50W fluorescent lamps at each one. Luminaries are placed in three rows as parallel to windows and recessed to suspended ceiling in 3.25m height (Figure 4). Maximum 1500 lux artificial illumination level is provided on working plane by this illumination system. A total of 12 fluorescent lamps, each of which connected individually to dimmable electronic ballasts are regulated by the Zumtobel LUXMATE bar system. This bar system enables the regulation of each lamp either automatically or manually. Illumination level inside office can be adjusted automatically depending on outside daylight level by daylight sensor placed in the volume looking window. Or, alternatively luminous flux of each lamp can be brought into desired level between 3% and 100% by user through remote control. The illumination levels on the working plane (daylight plus artificial light) determined by a sensor placed on the horizontal working plane are continuously recorded in computer using a data connection unit (Data Electronics Data Taker-DT600) are stored with desired time intervals.

3.2. Procedure

A total 15 subject who work in an office environment, are invited to sit in the test office for two hours periods to execute their normal and regular work (reading-writing, mutual discussions, working with computer and talking on telephone, etc.). During the first three half-hours sessions, lighting control system has been adjusted in order to provide 300 lux, 600 lux, and 1000 lux constant illumination level respectively on working plane. Subjects have continued their normal, regular work with half-hour periods on these three separate illumination levels classified as low, medium, and high respectively. Subjects have been asked to spend 5 minutes at least to adapt to each different illumination level and then to make their decisions.

At the end of three-half hour periods, subjects have been asked which illumination level they have felt themselves more comfortable. In addition, it has been among questions directed to the subjects whether their preferred illumination level has been fully suitable to their respective personal requirements or not. Whereas, during last half-hour period, opportunity has been granted to subjects to adjust, the illumination level according to their respective requirements.

Subjects, whose self-adjusted values are in adaptation with their preferred values among low, medium, high illumination levels, have been classified as "satisfied" from lighting control systems. The rest is classified as "not satisfied".

3.3. Discussions of the Experimental Results

Out of 15 subjects participating to the experiment, 7 are females and 8 are males. Age of two subjects is under 25 years, 6 are between 25 and 35 years, and 7 are more than 35 years. Only 2 subjects have been working under office ambience (without lighting control system) between 6 months and 3 years period. Remaining subjects are persons who have worked under office ambience for more than 3 years period. It has been observed that there has been an adaptation between value adjusted by them and illumination level preferred by them among automatically adjusted values by five subjects out of 15. Under this condition, only 33% of participants to the experiment could be classified as "satisfied" from existing lighting control system.

However, 3 persons out of these five classified as "satisfied" have preferred medium illumination level, one high illumination level, and one low illumination level. Under this condition, it is not possible to satisfy all of these persons with single lighting system adjusted in the manner of keeping fixed at certain value illumination level on working plane.

Among persons satisfied from lighting control system, one is under 25 years age, three between 25 and 35, and one is older than 35 years. Persons, whose self-adjusted value is in adaptation with their preferred value, are all female subjects. It has been observed that female subjects have been more sensitive to systems and that they have behaved more selectively in determination of their respective requirements.

After automatically adjusted three half-hour periods, subjects have been asked which illumination level they have felt themselves more comfortable. In addition, another question has been asked whether they have been fully satisfied with one of the three different illumination levels. Great differences have been seen between answers given to this question and illumination levels adjusted by the subjects through remote control. When opportunity for control is granted to persons, in general, persons adjust the level to much higher values than values initially preferred by them. This condition reinforces and firmly supports the fact that systems with remote control may lead to energy power consumption more than required.

4. CONCLUSION

In conclusion of the inquiry and experimental studies, it is understood that requirements of persons differ from each other to a great extent. Under this condition, it is obvious and very clear that existing lighting control systems programmed to provide only single constant illumination level throughout year can not meet the visual and comfort requirements of persons. If personal illumination preferences, which vary depending on psychological and physiological factors, can be pre-estimated and then lighting control systems can be adjusted in accordance with these preferences, then systems can operate much more effectively and efficiently. However, this can only be possible by entering into systems the experimental results obtained with many subjects with long periods by the help of the appropriate teaching algorithms [6, 7].

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