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LIGHTING DESIGN FOR THE AGING EYES

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Abstract

Lighting allows users to accomplish their tasks, feel safe and understand the surrounding environment. Therefore, it is an inseparable component of buildings. Building codes, energy standards and regulations determine the required illuminances to provide visual comfort. However, the existing requirements are constituted considering healthy eyes only. Different visual comfort requirements for people with visual disabilities, in particular for elderly people, are not clear. The world's older population continues to grow remarkably. In fact, the illuminance requirements show great difference for elderly people. For instance, an average 60 years old eye requires three times more illuminance than an average 20 years old eye. Therefore, a lighting design that complies with the regulations may not satisfy elderly users' needs.

Elderly spend most of their time indoors thus indoor spaces should fulfill their needs. Indoor lighting design and visual comfort are vital to prevent accidents and falls. Though such technical information is critical, it has not sufficiently covered in literature from elderly users' perspective. For that reason within this study, technical lighting design recommendations for residential areas from previous research have been offered to obtain visual comfort for elderly users. Different visual requirements of each space type are emphasized to promote accessible

design for elderly. The research aims to contribute to literature and guide future research on elderly indoor comfort.

Keywords

Lighting Design, Aging Eyes, Lighting for Disabled, Accessible Design, Design for Elderly

1. Introduction

Lighting allows users to accomplish their tasks, feel safe, identify surrounding, read signs and instructions. When lighting is not sufficient, users may be unable to navigate independently, feel insecure or may not be able to differentiate between features in a building (Avci and Beyhan 2017; Centre for Excellence in Universal Design n.d.). Thus, lighting is one of the most important and least understood elements in designing interior environments (Brawley 2009). Lighting system should provide the required illumination for specific task, flexibility, color appearance, light distribution, daylight integration and control. In a well-designed lighting system, tasks can be performed easily (without any visual discomforts), desired mood can be set, and users can live safely. Lighting design should support users during their daily lives while maximizing abilities and minimizing challenges, especially for individuals with special requirements.

In order to fulfill the lighting requirements, different lighting approaches are present. Layered lighting design approach is one of the most common ones, which uses variety of lighting sources to accommodate space and visually aid everyday tasks. Briefly, this approach includes three layers: ambient (which also refers as overall or general) layer, task layer and focal/decorative layer (Karlen 2004). The core layer of this approach is ambient layer, which provides a uniform lighting throughout the space. Ambient layer enables to perform basic visual tasks (such as walking around, conversation, and identifying objects). It is important to have an ambient layer for all kinds of spaces considering general use or maintenance. The second layer is called task layer, which illuminates a specific area with higher levels of light (such as reading or sewing area). Task layer also helps to save energy since it only illuminates the areas where the task is taken place. Focal/decorative layer is the final layer that helps to stylize and enhance architectural features. It may highlight artworks or special architectural features of the space. Though it is not mandatory to have a focal lighting layer, it helps to create mood and character. In successful lighting design installations, all three layers are implemented.

Previously discussed layered approach only includes artificial lighting; however, lighting design is not only limited with luminaires and control systems but also daylight penetration, glazing and interior surfaces play essential roles. Daylight from side windows or skylights may contribute to interior illuminance levels. When openings, orientation and glazing are cogitated, substantial amount of daylight can be obtained. Daylight can save significant amount of energy which normally be consumed to illuminate spaces artificially. On the other hand, if precautions are not taken, daylight might cause visual problems such as glare or unwanted reflections too. Having shadings (interior/exterior) can help to overcome glare yet also limit the daylight penetration. The determination of openings, shadings and the choice of glazing really matters to prevent daylight related visual problems.

Recently, elderly population proportion exceeds by 10% in more than 70 countries and aging becomes a global population issue (Leung, Yu, and Chong 2017). As the population ages, designers must be prepared to meet all emerging needs of elderly. However, basic requirements of all humankind may seem similar, as we get older visual requirements change. Despite this change, existing lighting standards and regulations only deal with healthy and young eyes. However, eyes undergo various physical changes due to the aging. Elderly suffer from reduced visual ability and contrast sensitivity with depth perception, while glare sensitivity and light-dark adaptation diminish (Shikder, Mourshed, and Price 2012; Shikder, Price, and Mourshed 2010).The elderly eyes are more sensitive to glare compared to younger eyes. Commonly elderly suffer from occurred cloudiness images which makes it difficult to differentiate objects (Derungs Medical Lighting 2011). Besides certain eye related diseases (such as macular degeneration, cataracts, diabetic retinopathy, glaucoma, retinis pigmentosa, dementia etc.) may change visual requirements/expectations in different age groups (Derungs Medical Lighting 2011; Shikder, Mourshed, and Price 2012). For instance, the illumination requirement of an 80-year-old equals to ten times of a young adult's requirements (on average). Due to that reason, elderly may be exposed to very low levels of illuminance in a space, which is illuminated according to healthy young eyes (Nioi et al. 2017). More specifically, some ailments causes difficulties with recognition and perception of the space. For instance a dementia patient may face difficulties to adequately process and react to environmental stimuli (Derungs Medical Lighting 2011). Therefore in spaces occupied by the elderly, these physiological changes in the optical system

requires meticulous considerations on lighting requirements (Shikder, Mourshed, and Price 2012).

In addition to the restrictions due to physiological changes, insufficient illuminance levels have been attributed to sleep disorders, depression and diminished social interactions (Eilertsen et al. 2016; Nioi et al. 2017). Specifically, in lack of adequate light, disruption can occur in the sleep patterns for elderly (and those with dementia and Alzheimer's) which can cause confusions in circadian rhythm. Circadian rhythm is a process of biological clock, found in all living creatures that regulates body functions (such as releasing hormones, regulating sleep cycle) according to the daylight exposure (Bellia, Pedace, and Barbato 2014). Circadian rhythm is affected by changes in light intensity during a 24 hour period, so when they are exposed to constant and high illuminance levels, their circadian rhythm is interrupted (Ampt, Harris, and Maxwell 2008). Disruption of circadian rhythm lead to weight gain, slower thinking, and psychological problems such as depression (Disruption Of Circadian Rhythms Affects Both Brain And Body, Mouse Study Finds -- ScienceDaily 2009).

2. Lighting Requirements of Elderly in Residential Areas

Elderly people spend most of their time indoors, especially in residential areas (Institute of Medicine of the National Academies 2011). Therefore, in order to prevent visual-based problems, residential areas occupied by elderly need special attention in terms of lighting design. Lighting system should meet the visual requirements while enriching the indoor experience. However, each space is unique (due to the furnishings, type of actions and functions), therefore requires special and differential treatment. The recommended values of illuminance requirement, color rendering index and unified glare rating in lighting standards are listed for healthy young eyes only (TMMOB 2011), and does not represent visual requirements of elderly. Due that reason, within this study, each residential area type is discussed considering elderly users.

As the methodology of this study, a general simplification on architectural features was used for each space type. Since residential areas can show great difference in terms of geometric, physical and environmental properties, all characteristic properties which may affect indoor visual comfort (such as window area, shadings, glazing type, orientation, luminaire type, lamp

type, surface colors etc.) are neglected. Each space type is considered with the main tasks taking place and the visual requirements of those tasks/functions.

The aim of this study is to provide an overview of the evidence in the literature on residential areas occupied by elderly. The hypothesis is that if sufficient illuminance levels are achieved with glare-free lighting, it provides independence and accident-free living for elderly. In the contrary case, poor lighting, unfavorable illumination levels or reflections can cause serious falls, which may require major surgery and an extensive recovery period (Lord 2006). By preventing falls, medical and care expenses can be reduced. Besides, elderly users feel more insecure and get less social with poor lighting conditions. Therefore, within this study, visual comfort recommendations are made for residential spaces occupied by elderly.

2.1 Entrance/Circulation Areas

On entrance, safe and inviting atmosphere has to be provided. It is important to see the one on the other side of the door. Besides, if there are any level differences between sides, it should be noticed. Hard shadows and lack of contrasts can complicate perception. Using daylight efficiently can help to obtain contrasts and save energy. However if windows are positioned at the end of corridors, it creates difficulties on identifying the proximity of oncoming objects or people. On spaces where communication is important, lighting fixture (luminaires) should be position to illuminate users' face without causing glare. This also helps for people who lip-read (Centre for Excellence in Universal Design n.d.). For circulation areas min. 200-300 lux should be achieved over the work plane which is on eye level (140-160 cm above floor) and same amount of illuminance has to be provided on 10 cm above floor too. Wide range of mounting types can be used for these areas; such as surface mounted, recessed, wall mounted or suspended luminaires. It is important to have a combination of direct and indirect lighting, vacancy sensor or two-way switches (which enables to control same lighting from various locations). Layered lighting design approach can be implemented.

2.2 Kitchen

Various tasks (such as preparation, cooking, cutting, washing and eating) can be performed in kitchens. In order to fulfill the visual requirements of each task, layered lighting design approach can be implemented. Each task can be illuminated by task lightings that prevent glare or dark shadows. Separately controlled switches allow users to control over appearance and

reduce energy usage (California Lighting Technology Center 2008). Maximizing daylight in the kitchen as much as possible is recommended to provide adequate amount of light in the kitchen area. However, if glare is a risk, shadings can be used to prevent unwanted reflections. In the kitchen area, over countertop min. 500 lux is required. Lamps with high color rendering index should be preferred in kitchen area.

2.3 Bedroom

Bedroom lighting should be flexible for different types of usages and should not cause glare on either standing or laying position. So if downlights are used, they must be used with diffusers to avoid glare and reflection (Centre for Excellence in Universal Design n.d.). Lighting design should be flexible to fulfill different lighting requirements of bed area (such as reading, working, resting), care taking or monitoring. Layered lighting approach can be implemented for each specific task and ambient lighting can create desired atmosphere. Bed luminaires with swing arms or adjustable table lamps close to bed area helps users to control light direction easily. It is important to provide two-way switching in bedrooms so that users can control lights from bed as well as entrance. For care purposes, integrated care lighting that illuminates 85 cm above floor by min. 500 lux must be provided with direct/indirect lighting. Bedroom should also equipped with night light which is close to floor and helps navigation at night. For night light, lamps with blue light should be avoided for sleep quality and circadian rhythm (Harvard Health Letter 2012).

2.4 Living Room

Considering the variety of tasks, flexible and layered lighting solutions have to be proposed in living rooms. Providing separately controlled luminaires for specific tasks (reading, working, resting) can help users to obtain the requested atmosphere. Contrasts can help users to recognize and identify objects easily. Therefore providing 300-1000 lux throughout the space can be sufficient. Especially areas close to floor should be carefully illuminated (100-500 lux) to prevent falls and accidents (Derungs Medical Lighting 2011).Glare free vision with high color rendering is demandable.

2.5 Toilet/Bathroom

On lavatory areas, in addition to general lighting that aims to evenly illuminate area, task lighting with high color rendering (80 and above) on mirror area (which cylindrically illuminates

face) should be provided. Approximately 200-500 lux is required for lavatory areas yet illuminating area near to floor is vital to prevent accidents (Derungs Licht AG 2017). Shiny materials that may cause unwanted reflections should be avoided.

3. Conclusion

Lighting design is a process of integration light to architecture to provide comfort, safety and aesthetics. Many design approaches are available for lighting design yet when we design for elderly; it requires special consideration to provide comfort and enjoyment while keeping them safe. A well-designed elderly oriented lighting provides glare free vision with sufficient illuminance levels. Any possible source of glare (such as windows, skylights, and luminaires) should be carefully chosen and located. Type of glazing can reduce glare, thus glazing with low visible transmittance (VT) values may be preferred (Lawrence Berkeley National Laboratory 1997). Besides VT, using interior/exterior shadings (blinds, drapes, light shelves etc.) helps to reduce glare. Having contrasts make objects/spaces more visible, and helps to detect differences between objects. On horizontal work plane, illuminance levels should not change suddenly, soft transitions which promotes adaptation can prevent accidents and falls (National Institute of Building Sciences 2015). Since elderly users may face difficulties in circulation, it is significantly important to have easily accessible switches and controls.

Within this study, in order to provide elderly friendly residential areas, recommendations are made over to improve visual comfort conditions and attaining user satisfaction that enhances residential area experience. This review has identified the current state of research on visual comfort of elderly. Although several extensive studies are identified, there was a general lack of consideration of the lighting design with architectural features and elderly satisfaction. Due to the lack of strategies and tools to measure subjective concepts (perception, privacy, satisfaction of users) and architectural characteristics, recommendations remain in the qualitative realm or have simple quantitative ratings. Governments have increased funding to elderly care services, and aim to enhance elderly users' satisfaction through facilities. Therefore future research focused on the lighting standards based on elderly user profile, or a perspective of architectural lighting design with relation to elderly requirements are crucial to governments while improving these elderly friendly facilities.

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