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ScienceDirect

Energy Procedia 136 (2017) 102–108

Energy Procedia

www.elsevier.com/locate/procedia

4th International Conference on Energy and Environment Research, ICEER 2017, 17-20 July 2017, Porto, Portugal

Improving visual comfort and energy efficiency in existing classrooms using passive daylighting techniques

Baraa J. Al-Khatatbeh[a], Shouib Nouh Ma'bdeh[a,*]

[a]*Departmentof Architecture, Jordan University of Science and Technology, Irbid 22110, Jordan*

Abstract

In classrooms, light levels are directly related to energy consumption; due to the use of artificial lighting. Hence, this study aims to improve the visual comfort and energy efficiency in existing classrooms, by investigating various retrofit methods for passive daylight techniques, in northerly oriented classrooms at Jordan University of Science and Technology (JUST). Data of this research are obtained using computer simulation and real measurements. The combination of the clerestory window and the anidolic ceiling directed toward the south provided about 62% of the lighting level required in the classroom, and it decreased the energy consumption required for lighting, heating, and cooling by 16.3%.

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Peer-review under responsibility of the scientific committee of the 4th International Conference on Energy and Environment Research.

*Keywords:*Classrooms; energy efficeincy; passive daylight techniques;retrofit; simulation; thermal comfort; visual comfort

1. Introduction

Kr'uger and Zannin [1] stated that the indoor environmental quality of classrooms has a great effect on the quality of teaching. Santoli et al. and Erhorn et al. [2-3] indicated that the most notable similarities between most of the exiting classrooms are the high-energy consumption, and the need for retrofitting in order to enhance the comfort level. According to Winterbottom and Wilkins [4],visual comfort is an important aspect of good indoor environmental quality in classrooms. Abdelatiaet al. [5] indicated that it has a major contribution to the creation of

* Corresponding author. Tel.: +962797793379
E-mail address:snmabdeh@just.edu.jo

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Peer-review under responsibility of the scientific committee of the 4th International Conference on Energy and Environment Research.
10.1016/j.egypro.2017.10.294

adequate educational environment. Visual comfort can be achieved either by artificial lighting or by daylighting. Recent results from Winterbottom and Wilkins [4] have found that students and teachers have different tendencies toward the preferred type and level of lighting, while most of researchers emphasized on the importance of daylighting.

Energy for buildings is the most important sector of energy demand, providing cooling, heating, water heating, lighting as major uses. In educational facilities and classrooms, it is important to provide comfortable indoor environment in parallel to adequate energy use. Dascalakia and Sermpetzoglou [6] state that the high occupancy of classrooms calls for high standards of ventilation, lighting and thermal conditions.

This paper investigates different retrofits for passive daylight techniques, to enhance daylight provision and reduce energy consumption in selected educational spaces. It compares various passive daylighting techniques and combinations in order to optimize lighting comfort level, without affecting thermal comfort or increasing energy consumption of the space under investigation. These techniques will be fixed with minimal damage to the building envelop of the selected spaces under investigation.

1.1. Lighting codes for classrooms

According to Yener [7], the illuminance in classrooms should be suitable for activities like writing and reading on chalkboard and desks. Kruger and Dorigo [8] found that every country has its own codes of lighting for classrooms, but it all ranges from 300-500 lux. Most of the codes originate to the ones released by the Illuminating Engineering Society of North America (IESNA) and the European Standards (CEN). Both of them recommend a target illuminance of 300 lux for classrooms as stated by Yo and Su[9]. The EN 12464-1, the European standard for indoor lighting, has detailed the recommended values of illuminance and uniformity in classrooms as follows [10]:

- Illuminance level on task plane 300 lux, and on the board 500 lux,
- The minimum daylight factor in classrooms is 2% by Lechner[11],
- The Daylight Glare Index (DGI) is recommended to be 20 according to Baker and Steemers[12].

1.2. Sample of the space under investigation

A sample classroom represents about 60% of typical classrooms of JUST was chosen. The dimensions of the classroom are 7.1m long and 8.2m wide. All the classrooms of JUST are accessed through single loaded corridors of 2.7 m width (Fig.1). The height of the classroom is 3.5m, ending with a false ceiling as shown in section A-A (Fig. 2). The classroom is sidelit with narrow and vertical openings directed toward north. The window to wall ratio (WWR) is about 19%. The typical capacity of each classroom is 48 students.

Since the most important attribute of the material for lighting design is the material reflectance; reflectance of various materials used to build up the classroom were measured using a Lightmeter, as shown in Table 1.

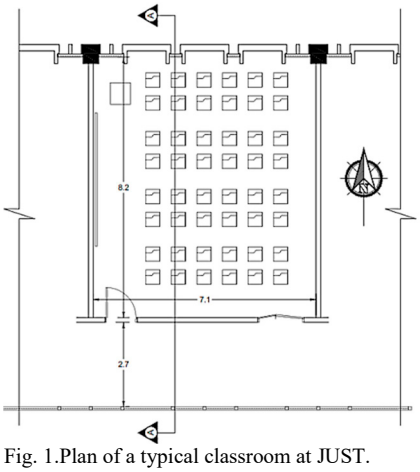

Fig. 1.Plan of a typical classroom at JUST.

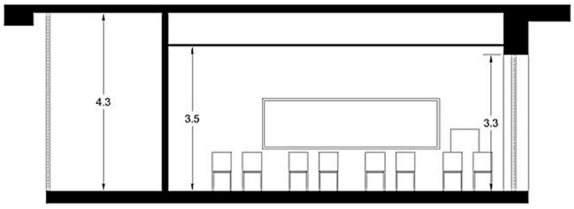

Fig. 2.Section of a typical classroom at JUST.

Table1. Materials' reflectance of a typical classroom at JUST.

Member	Material reflectance
Ceiling	0.70
Floor	0.44
Walls	0.56
Glass (transmission)	0.90

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