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Article

Energy efficiency study of an academic classroom of an educational center under NOM-007-ENER-2014 and NOM-025-STPS-2008

Estudio de eficiencia energética del aula académica de un centro educativo bajo la norma NOM-007-ENER-2014 y NOM-025-STPS-2008

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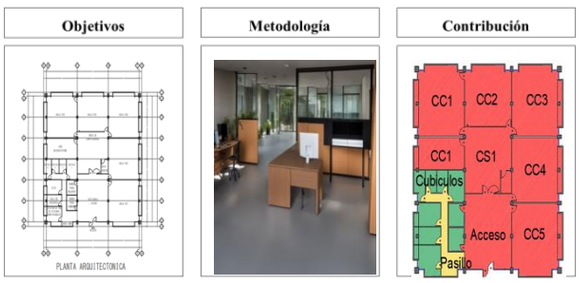
Abstract

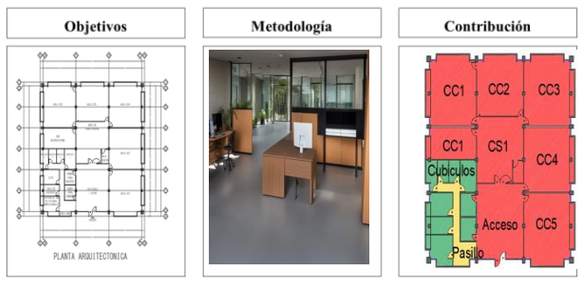
The energy efficiency of an academic classroom is presented as an important alternative to avoid the excessive use of artificial air conditioning systems, thus reducing energy consumption and the environmental, social and economic impacts derived from said consumption. Currently, the official Mexican standards NOM-007-ENER-2014 and NOM-025-STPS-2008 are used, efficiency and lighting conditions in buildings. The official Mexican standard NOM-0076-ENER-2014 establishes the levels of energy efficiency in terms of electrical power density for lighting with which lighting systems for general use of new non-residential buildings, extensions and modifications of existing ones must comply existing. While the official standard NOM-025-STPS-2008 establishes the minimum lighting conditions that every workplace must comply with. With the above, it turned out that based on the materials that currently make up the classroom envelope, it does not meet the standards established by the norm, which directly requires establishing a new design of the envelope that leads to reducing heat gains towards the interior of space.



Efficiency, reducing, environmental

Resumen

La eficiencia energética de un aula académica se presenta como una importante alternativa para evitar el uso excesivo de sistemas de climatización artificial, reduciendo así, el consumo energético y los impactos ambientales, sociales y económicos derivados de dicho consumo. En la actualidad se emplean las normas oficiales mexicanas NOM-007-ENER-2014 y NOM-025-STPS-2008, eficiencia y condiciones de iluminación en edificaciones. La norma oficial mexicana NOM-0076-ENER-2014 establece los niveles de eficiencia energética en términos de densidad de potencia eléctrica para alumbrado con los que deben cumplir los sistemas de alumbrado para uso general de edificios no residenciales nuevos, ampliaciones y modificaciones de los ya existentes. mientras que la norma oficial NOM-025-STPS-2008 establece las condiciones mínimas de iluminación que todo centro laboral debe cumplir. Con lo anterior resultó que con base a los materiales que actualmente conforma a la envolvente del aula no cumple con los estándares que establece la norma lo que en forma directa se debe de establecer un nuevo diseño de la envolvente que conlleve a disminuir las ganancias de calor hacia el interior del espacio.



Eficiencia, reducción, ambiente

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Introduction

Currently, electrical energy consumption in buildings through luminaires is between 18% and 20% of total consumption, which is why the importance of a correct location and selection of luminaires will have a direct impact on energy consumption in the home or building. That is why it is important to have control over the number of luminaires we need to properly light the work environment, the lack of luminaires would reduce visibility thus affecting the performance of the worker, while an excess of luminaires increases the cost and time in maintenance, in the same way can cause annoying flashes.

In order to have a better efficiency and a saving in the energy consumption that is used in terms of lighting in the facilities of the Instituto Tecnológico Superior de Huichapan (ITESHU), it is proposed to analyse all the facilities of the academic building 'computer systems', this floor has the following architectural spaces: five work laboratories for students, corridor, six cubicles for teachers and a common area.

The work laboratories are the areas that must have a higher number of lux than the other areas of the plant, as this is established by the official Mexican standard for lighting conditions in workplaces. The DiaLux programme will be used to analyse the luminaires that are installed and verify whether they meet the minimum requirements of the official Mexican standard for lighting conditions in workplaces.

If the requirements are not met, a lighting redesign should be carried out, seeking: a good proportion of visibility in order to achieve the required degree of precision and speed in the performance of tasks, lighting levels that reduce the effort required when working, and finally, lighting conditions that provide safety with the furniture and minimum glare and visual impairment.

This article will deal with the architectural survey of a computer laboratory in the 'computer systems' academic building, and its export to the lighting simulation programme in order to carry out the energy simulation of the architectural space.

Theoretical framework

Luxmeter

A luxmeter is an instrument that measures the illumination of a room or a focal point and requires an optical sensor (photodetector) to convert light into an electrical signal in order to measure its intensity. There are several types of photodetectors available on the market, such as phototransistors or LDRs. But the one used by luxmeters is the photodiode due to its linearity and low response time [1].

Box 1

Figure 1
Luxmeter used for illumination measurement
Source: [Own authorship 2024]

DIAlux

Dialux allows you to develop a lighting design for any architectural or architectural project. In addition, use images and web fonts in a variety of formats to develop your lighting plan. It also helps to create all the necessary documentation for the presentation of our lighting projects, making it clear and understandable for both clients and non-advanced users [2].

AutoCAD

AutoCAD is a standard program used by architects to develop sketches, drawings, plans, designs and details that must meet certain parameters in the client's requirements. In addition, AutoCAD is a versatile program that allows you to develop architectural, industrial, mechanical, graphic design and engineering projects. Capable of viewing designs in 2D and 3D [3].

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Methodology

Geographical survey of the building.

The building is located in the municipality of Huichapan in the state of Hidalgo, the area of study is a computer laboratory type building, for its analysis an architectural survey of the construction was carried out. In order to export the survey to the software, it was necessary to draw it in a CAD type software, in which the plans of the three architectural floors were drawn separately. With the measurements obtained in the survey, the electrical plans of these floors were drawn, as well as a plan with the distribution of the objects on each floor.

Climatology

The municipal territory has the following climates with their respective percentages: semi-dry temperate (88.0%), sub-humid temperate with summer rains, lower humidity (10.0%) and sub-humid temperate with summer rains, medium humidity (2.0%).

Box 2

Figure 2 Geolocation of the building
Source: [Own authorship 2024]

Building análisis

The building is a computer laboratory (computer centre) is a building that has 5 spaces of the classroom and computer centre type. We will analyse the amount of power used to light the interiors, as well as the amount of lumens that they manage to contribute to this area in order to achieve an efficient and, above all, safe space.

The facades of the building include a glazed area.

User analysis

The analysed space is used by students from different semesters of the computer systems degree (morning and afternoon shift) as well as by teachers, who give classes. Once the previous stage was completed, the analysis began virtually by means of the NOM-007-ENER-2011 standard [5], which consists of introducing energy efficiency in the installations with respect to the luminaires that are present, and also by means of the NOM-025-STPS-2008 [4], introducing the good use of the luminaires with respect to the luminaires that each area presents.

Architectural Survey

The building is located in the state of Hidalgo in the municipality of Huichapan, the Abundio Martínez computer centre, for its analysis a survey of the structure was carried out using AutoCAD software, which served as a guide to shape the structure in a 2D drawing, with the measurements obtained in the survey the structural plan was drawn up, as well as the distribution of the objects that were inside.

Box 3

Figure 3 Creation of the plan in AutoCAD
Source: [Own authorship 2024]

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Simulation in AutoCAD

Box 4

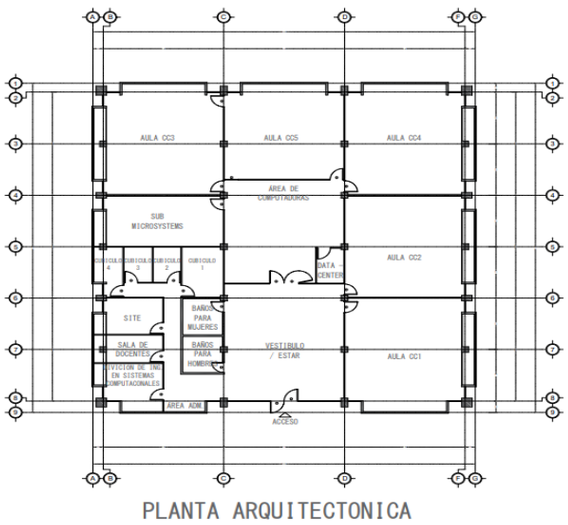

Figure 4

Abundio Martínez computer centre

Source: [Own authorship 2024]

Simulation in Dialux

Dialux Evo software was used as part of the methodology to better visualise the amount of lighting in the academic spaces and corridors, as well as the electrical power consumed by the building.

Box 5

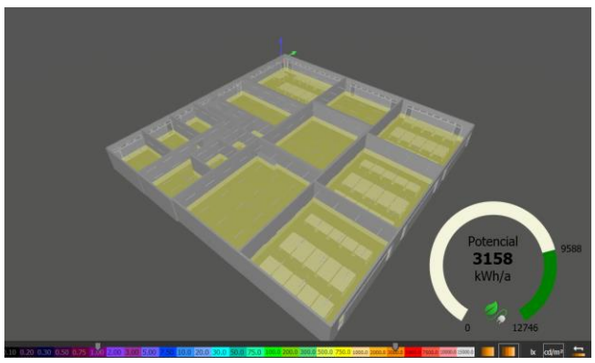

Figure 5

Simulation in DIALux evo 11.0

Source: [Own authorship 2024]

Virtual Model

Renderings of the interiors and façade of the building under analysis were made. The following shows the renderings in different perspectives

Box 6

Figure 6

Façade of the Abundio Martínez Laboratory

Source: [Own authorship 2024]

Box 7

Figure 7

Interior of the laboratory

Source: [Own authorship 2024]

Box 8

Figure 8

Main entrance to the building

Source: [Own authorship 2024]

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Results

The single-level computer laboratory has 130 fluorescent-type luminaires with a total of 106,470 (lm), a total power of 5150 (W) and an electrical power density for lighting of 6.83 W/m^2. lighting of 6.83 W/m^2. The calculation surfaces show that none of the classrooms (CC1, CC2, CC3, CC4, CC5) have the minimum number of lumens, being 500 for the computer room, while all the cubicles manage to exceed the maximum illuminance, and finally, the corridor and the entrance area manage to reach the minimum illuminance. The above can be seen in table 1.

Box 9

Table 1

Number of lumens per zone

Entrance	236 tx	Aula CC1	356 tx
Computer room	265 tx	Aula CC2	264 tx
Data centre	116 tx	Aula CC3	351 tx
Sub-microsystem	211 tx	Aula CC4	344 tx
Toilets	140 tx	Aula CC5	362 tx
Corridors	180 tx	Cubículos	297 tx

Source: [Own authorship 2024]

The table above does not comply with the number of lumens requested by the NOM-025-STPS-2008 standard (table 2), (table 3) DOES NOT COMPLY.

Box 10

Table 2

The number of lumens requested by NOM-025-STPS-2008 is shown

Visual Workplace Task	Work Area	Minimum Illumination Levels (lux))
Outdoor: distinguish traffic area, walking, surveillance, vehicle movement.	General exteriors: courtyards and car parks.	20
Indoors: distinguish traffic area, walking, surveillance, vehicle movement.	General interiors: lightly used warehouses, corridors, stairways, covered parking areas, underground mine workings, emergency lighting.	50
Indoors.	Circulation areas and corridors; waiting rooms; rest rooms; store rooms; platforms; boiler rooms.	100
Simple visual requirement: visual inspection, part counting, bench and machine work.	storage rooms; platforms; boiler rooms.	200
Moderate detail distinction: simple assembly, medium bench and machine work, simple inspection, packaging and clerical work.	Personnel services: rough storage, reception and dispatch, guard houses, compressor rooms, and pailage.	300
Clear distinction of detail: delicate machining and finishing, moderately difficult inspection assembly, data capture and processing, handling of instruments and laboratory equipment.	Workshops: packaging and assembly areas, classrooms and offices.	500
Fine detail distinction: precision machining, assembly and inspection of delicate work, handling precision instruments and equipment, handling small parts.	Precision workshops: computer rooms, drawing areas, laboratories.	750
High accuracy in detail distinction: assembly, processing and inspection of small and complex parts, finishing with fine polishing.	High-precision workshops: painting and surface finishing and quality control laboratories.	1,000
High degree of specialisation in distinguishing details.	Highly accurate process. Execution of visual tasks: - low contrast and very small size for prolonged periods of time; - accurate and very long, and y special tasks of extremely low contrast and small size.	2,000

Source: [Own authorship 2024]

DPEA results according to NOM 007 ENER 2014 standard

The calculation to obtain the total DPEA of the building is shown below.

As requested by the NOM 007 ENER 2014 standard, the calculation is well below the requirements of this standard.

Calculation of DPEA (total concentrated load for lighting total illuminated area))

$$DPEA = \frac{Total\ connected\ load\ for\ lighting}{Total\ illuminated\ area}$$

Total connected load for luminaire: 5,150W

Total illuminated area: 753.77m^2

$$DPEA = \frac{5{,}150\ W}{753.77m2} = 6.83\ W/m2$$

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Box 11

Table 3

The DPEA table by architectural building type is shown

Type of building	DPEA (w/m^2)
Offices	
Offices	12
Schools and other educational institutions	
Schools or educational institutions	14
Libraries	15

Source: [Own authorship 2024]

Box 12

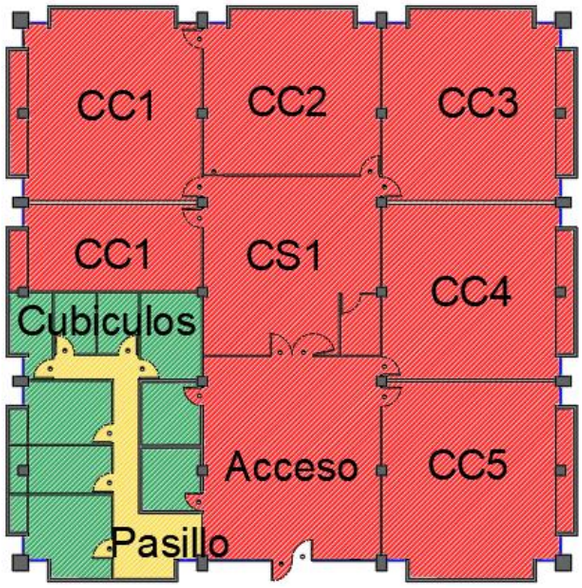

Figure 9

Shown are the spaces that comply with the standard (green) and those that do not (red)

Source: [Own authorship 2024]

Conclusions

We concluded that most of the architectural spaces in the Abundio Martínez laboratory do not comply with the parameters established by the safety and energy efficiency standards NOM-007-ENER-2014 and NOM-025-STPS-2008.

Therefore, a luminaire restructuring could be carried out to avoid possible accidents or damage to health.

Once the analysis had been carried out, negative results were obtained in terms of energy efficiency in accordance with the standard's methodology with the methodology of the standard, according to the standard NOM-007-ENER-2014, the efficiency is very low, because the DPEA, we get very low to the 14 that marks the standard.

Therefore, in terms of the calculation of the standard and energy efficiency must comply with the specifications of the building with respect to the reference building, said the above is determined that the approach around the safety of the standard NOM-025-STPS-2008.

The level of lux is very low, specifically in the areas where students take classes or carry out their academic activities, the amount of lux is less than that required by the standard for buildings or spaces such as computer labs or classrooms.

When carrying out other analyses such as the percentage of solar radiation, these values are disregarded due to the low influence they have on the classrooms because of the opaque glass windows.

Statements

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

JCRU conceptualisation, methodology and software; JCRU and ZBTT validation and writing; MBA review.

Availability of data and materials

All material and data will be made available for consultation on direct request to the corresponding author, subject to applicable ethical restrictions.

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