ISSN 2531-2162

Volume 8, Issue 19 – e20240819 January – December – 2024

Journal of Architecture and Design

Journal of Architecture and Design, Volume 8, Issue 19: e20240819 January – December 2024, is a Continuous publication - Journal edited by ECORFAN-Spain. Matacerquillas Street 38, CP: 28411. Moralzarzal-Madrid. WEB: http://www.ecorfan.org/spain/rj_arquitectura_dis.php, revista@ecorfan.org. Editor in Chief: JALIRI-CASTELLON, María Carla Konradis, PhD. ISSN 2531-2162. Responsible for the last update of this issue ECORFAN Computer Unit. Imelda Escamilla Bouchán, PhD. Vladimir Luna Soto, PhD. Updated as of December 31, 2024.

Journal of Architecture and Design

Definition of the Journal

Scientific Objectives

Support the International Scientific Community in its written production of Science, Technology in Innovation in the Humanities and Behavioral Sciences Area, in the Sub-disciplines of international architecture, technological innovation in architecture, industrial design, business design techniques, multimedia design, advertising design, web system design, residential architecture.

ECORFAN-México SC is a Scientific and Technological Company that contributes to the formation of Human Resources focused on continuity in the critical analysis of International Research and is attached to the RENIECYT of CONAHCYT with number 1702902, its commitment is to disseminate the research and contributions of the International Scientific Community, academic institutions, agencies and entities of the public and private sectors and contribute to the linking of researchers who carry out scientific activities, technological developments and training of specialized human resources with governments, companies and social organizations.

Encourage the dialogue of the International Scientific Community with other study centers in Mexico and abroad and promote a broad incorporation of academics, specialists and researchers to the Serial publication in Science Niches of Autonomous Universities - State Public Universities - Federal IES - Polytechnic Universities - Technological Universities - Federal Technological Institutes - Normal Schools - Decentralized Technological Institutes - Intercultural Universities - S&T Councils - CONAHCYT Research Centers.

Scope, Coverage and Audience

Journal of Architecture and Design is a Journal edited by ECORFAN-México S.C in its Holding with a repository in Spain, it is a peer-reviewed and indexed scientific publication on a quarterly basis. It supports a wide range of contents that are evaluated by academic peers by the Double-Blind method, around topics related to the theory and practice of international architecture, technological innovation in architecture, industrial design, business design techniques, multimedia design, advertising design, web system design, residential architecture with diverse approaches and perspectives that contribute to the dissemination of the development of Science, Technology and Innovation that allow arguments related to decision-making and influence the formulation of international policies in the Field of Science Engineering and Technology. The editorial horizon of ECORFAN-México® extends beyond academia and integrates other segments of research and analysis outside of that field, as long as they meet the requirements of argumentative and scientific rigor, in addition to addressing topics of general and current interest of the International Scientific Society.

Editorial Committee

Arbitration Committee

GARCÍA - Y BARRAGÁN, Luis Felipe. PhD
Universidad Nacional Autónoma de México

VILLALOBOS - ALONZO, María de los Ángeles. PhD
Universidad Popular Autónoma del Estado de Puebla

ROMÁN - KALISCH, Manuel Arturo. PhD
Universidad Nacional Autónoma de México

CHAVEZ - GONZALEZ, Guadalupe. PhD
Universidad Autónoma de Nuevo León

DE LA MORA - ESPINOSA, Rosa Imelda. PhD
Universidad Autónoma de Querétaro

GARCÍA - VILLANUEVA, Jorge. PhD
Universidad Nacional Autónoma de México

CORTÉS - DILLANES, Yolanda Emperatriz. PhD
Centro Eleia

FIGUEROA - DÍAZ, María Elena. PhD
Universidad Nacional Autónoma de México

DELGADO - CAMPOS, Genaro Javier. PhD
Universidad Nacional Autónoma de México

LINDOR, Moïse. PhD
El Colegio de Tlaxcala

PADILLA - CASTRO, Laura. PhD
Universidad Autónoma del Estado de Morelos

Assignment of Rights

The sending of an Article to ECORFAN Journal Republic of Peru emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Originality Format for its Article.

The authors sign the Authorization Format for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Republic of Peru considers pertinent for disclosure and diffusion of its Article its Rights of Work.

Declaration of Authorship

Indicate the Name of Author and Coauthors at most in the participation of the Article and indicate in extensive the Institutional Affiliation indicating the Department.

Identify the Name of Author and Coauthors at most with the CVU Scholarship Number-PNPC or SNI-CONAHCYT- Indicating the Researcher Level and their Google Scholar Profile to verify their Citation Level and H index.

Identify the Name of Author and Coauthors at most in the Science and Technology Profiles widely accepted by the International Scientific Community ORC ID - Researcher ID Thomson - arXiv Author ID - PubMed Author ID - Open ID respectively.

Indicate the contact for correspondence to the Author (Mail and Telephone) and indicate the Researcher who contributes as the first Author of the Article.

Plagiarism Detection

All Articles will be tested by plagiarism software PLAGSCAN if a plagiarism level is detected Positive will not be sent to arbitration and will be rescinded of the reception of the Article notifying the Authors responsible, claiming that academic plagiarism is criminalized in the Penal Code.

Arbitration Process

All Articles will be evaluated by academic peers by the Double-Blind method, the Arbitration Approval is a requirement for the Editorial Board to make a final decision that will be final in all cases. MARVID® is a derivative brand of ECORFAN® specialized in providing the expert evaluators all of them with Doctorate degree and distinction of International Researchers in the respective Councils of Science and Technology the counterpart of CONAHCYT for the chapters of America-Europe-Asia-Africa and Oceania. The identification of the authorship should only appear on a first removable page, in order to ensure that the Arbitration process is anonymous and covers the following stages: Identification of the Journal with its author occupation rate - Identification of Authors and Coauthors - Detection of plagiarism PLAGSCAN - Review of Formats of Authorization and Originality-Allocation to the Editorial Board- Allocation of the pair of Expert Arbitrators-Notification of Arbitration - Declaration of observations to the Author-Verification of Article Modified for Editing-Publication.

Instructions for Scientific, Technological and Innovation Publication

Knowledge Area

The works must be unpublished and refer to issues of international architecture, technological innovation in architecture, industrial design, business design techniques, multimedia design, advertising design, web system design, residential architecture and other topics related to Engineering Sciences and Technology.

Presentation of the Content

In Issue 19, is presented an article *Structural analysis of a lifting platform for autonomous vertical vehicular parking, by* Betanzos-Castillo, Francisco, Fuentes-Castañeda, Pilar and Cortez-Solis, Reynaldo, with adscription at Tecnológico Nacional de México – TES Valle de Bravo, in the next article *5's diagnosis in the substation department of the western transmission area*, by Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis, with adscription at Tecnológico Nacional de México Campus Occidente del Estado de Hidalgo, in the next section *Optimization of preventive maintenance in the design of photovoltaic plants*, by Chavira-Álvarez, Alberto, Pérez-Ortega, Eva Claudia and Esparza-Delgado, María Del Carmen, with adscription at Universidad Tecnológica de Chihuahua, in the next section *Augmented reality in the educational context for the digitalization of products and mathematical applications,* by Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén, with adscription at Universidad Tecnológica de la Huasteca Hidalguense, in the next section Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx., by Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar, with adscription at Universidad Autónoma de San Luis Potosí. As final article we present *Lighting design proposal for the facade of an historic art building*, by Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan, with adscription at TecNM/IT de Pachuca.

Content

Journal of Architecture and Design 8[19]1-8: e10819108
Article

Structural analysis of a lifting platform for autonomous vertical vehicular parking

Análisis estructural de una plataforma de elevación para estacionamiento vehicular vertical autónomo

Betanzos-Castillo, Francisco*[a], Fuentes-Castañeda, Pilar[b] and Cortez-Solis, Reynaldo[c]

[a] Tecnológico Nacional de México - TES Valle de Bravo • AIE-1532-2022 • 0000-0002-7245-703X • 206209
[b] Tecnológico Nacional de México - TES Valle de Bravo • KUD-2889-2024 • 0000-0001-6567-9614 • 428699
[c] Tecnológico Nacional de México - TES Valle de Bravo • KUD-2900-2024 • 0000-0001-7519-1815 • 1113392

CONAHCYT classification:

Area: Engineering
Field: Engineering
Discipline: Mechanical Engineering
Subdiscipline: Mechanical design

https://doi.org/10.35429/JAD.2024.8.19.1.8
History of the article:
Received: January 17, 2024
Accepted: June 30, 2024

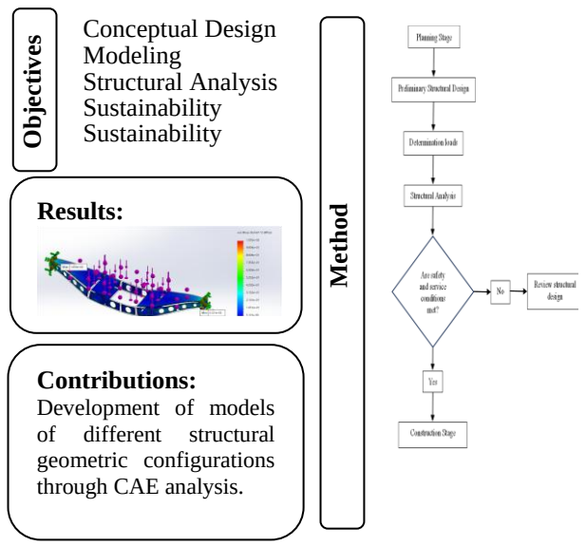
* ✉ [francisco.bc@vbravo.tecnm.mx]

Abstract

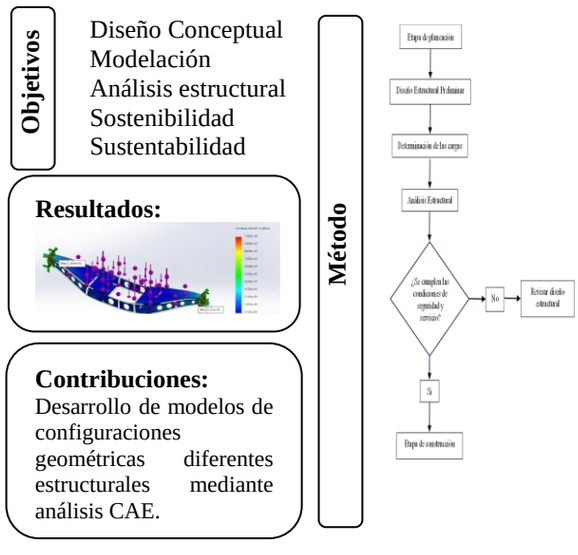
A problem that has become latent in urban areas, cities, shopping malls, among others, is the space available for parking cars, coupled with the increase of the vehicle fleet and few spaces established to operate as parking lots. As an alternative solution, the conceptual design of a vertical autonomous parking with a vision oriented to the I4.0 industry was developed. The design, modeling and structural analysis was carried out using computer aided engineering (CAE) of a central platform where vehicles are accommodated upon arrival, this will be raised and finally transferred on a structure divided into different levels, making comparisons according to the configurations and design parameters. Finally, simulations were obtained by means of Finite Element Analysis (FEA), which allowed the realization of different configurations through the use of software to verify if the use of the proposed material is viable for future works in a real way.

Resumen

Una problemática que se ha hecho latente en las zonas urbanas, ciudades, centros comerciales, entre otros, es el espacio disponible para estacionar automóviles, aunado al aumento del parque vehicular y pocos espacios establecidos para operar como estacionamientos. Como alternativa de solución se desarrolló el diseño conceptual de un estacionamiento autónomo vertical con visión orientada a la industria I4.0. Se realizó el diseño, modelación y análisis estructural empleando ingeniería asistida por computadora (CAE) de una plataforma central donde los vehículos al llegar son alojados, esta se elevará y finalmente los transferirá sobre una estructura dividida en diferentes niveles, realizando las comparativas de acuerdo las configuraciones y parámetros de diseño. Finalmente, se obtuvieron simulaciones por medio de Análisis por Elemento Finito (FEA), lo que permitió realizar diferentes configuraciones mediante el empleo de software para verificar si es viable el uso del material propuesto para trabajos futuros de manera real.



FEA, Simulation, Vertical parking



FEA, Simulación, Estacionamiento vertical

Citation: Betanzos-Castillo, Francisco, Fuentes-Castañeda, Pilar and Cortez-Solis, Reynaldo. [2024]. Structural analysis of a lifting platform for autonomous vertical vehicular parking. Journal of Architecture and Design. 8[19]-1-8: e10819108.

Introduction

Since the middle of the last century, Latin American cities have experienced a rapid growth of their urban centers, which has resulted in a variety of problems such as traffic congestion, environmental pollution, infrastructure deterioration, among others (Rodríguez A. G. y Ramos J. L., 2009). Aiming to mitigate the limitations in the current parking infrastructure and address the global challenge of traffic congestion, propose a vehicle design scheme with vertical lift mechanisms and folding wings, which represents an innovative change for environmental protection, sustainable development and artificial intelligence (Yixu, Junying, & Kun, 2024). Nowadays it is very important to know that urban space is becoming more and more limited, the need for innovative solutions to optimize land use is becoming more and more constant. In this context, conceptualizing vertical parking support structures, in this case, emerges as an efficient and practical response to the growing demand for parking spaces.

Simulation of working machines is a phase of the process that makes it possible to substantially improve performance by facilitating the detection of anomalies not foreseen in the design phase, reducing the amount of real-life testing and also making it possible to analyze and evaluate the safety factor, reducing the probability of generating failures due to fatigue or overload (Galán Ávila, Avendaño Rodríguez, & Villalobos Correa, 2022). For this purpose, a design guideline involving system dynamics, load types and capacities must be defined. A prior strength analysis rule is established, which must be specified and applied (Halicioglu, Canan Dulger , & Tolga Bozdana, 2016).

Finite Element Analysis (FEA) is referred to as Finite Element Method (FEM), which is used in engineering to reduce the number of physical prototypes and run virtual experiments to optimize their designs (Rameshrao Yawale & Nivrutti Naik, 2021) (J.C.TORRES, 1998).

The basic idea of FEM is to divide the complex structure into a finite number of interconnected elements, to determine the loads acting on each node and to calculate the displacements in the direction of those loads, and thus obtain a result for the whole (Oguz Örmecioglu, Aydogdu, & Tugba Örmecioglu, 2024).

This project shows the results of the axisymmetric analysis of a lifting structure for an autonomous vertical parking, simulating the deformation with loads on the structure. The analysis is performed with simulation software, Ansys Workbench and SolidWorks, making a comparison between them to obtain a simulation closer to the real conditions requested at the time of its operation. With this structural analysis, we seek to explore the characteristics, advantages and key considerations associated with this type of structures, with the objective of understanding their performance and their impact in any environment.

The first section contains the project summary with a general description of the research conducted. The second section deals with the introduction of the project, in which the reader will understand the comparative and the main point of analysis. The third section shows the theoretical framework as the main support of the project to know terms and concepts that will be addressed in the CAE simulation, then the fourth section will show the methodology to be applied on the analysis of the structure, materials added to the 3D model, parameters, types of models to be used, meshing and comparisons made, finally the fifth section shows the results and conclusions found.

Methodology

Structural engineering is the science and art of safely and economically planning, designing and constructing structures to serve those purposes. Structural analysis is an integral part of any structural engineering project, whose function begins with the prediction of the behaviour of the structure.

Structural analysis is the prediction of the performance of a structure under prescribed loads and/or external effects, such as support movements and temperature changes. The characteristics of interest in the design performance of structures are (1) stresses or stress results, such as axial forces, shear forces, and bending moments; (2) deflections; and (3) support reactions, therefore, the analysis of structures usually involves the determination of these quantities as the cause of a loading condition.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Betanzos-Castillo, Francisco, Fuentes-Castañeda, Pilar and Cortez-Solis, Reynaldo. [2024]. Structural analysis of a lifting platform for autonomous vertical vehicular parking. Journal of Architecture and Design. 8[19]-1-8: e10819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

A structural engineering study is described by various stages using a flow chart, this indicates that it is an iterative process, and generally consists of the following steps (Kassimali, 2015):

Box 1

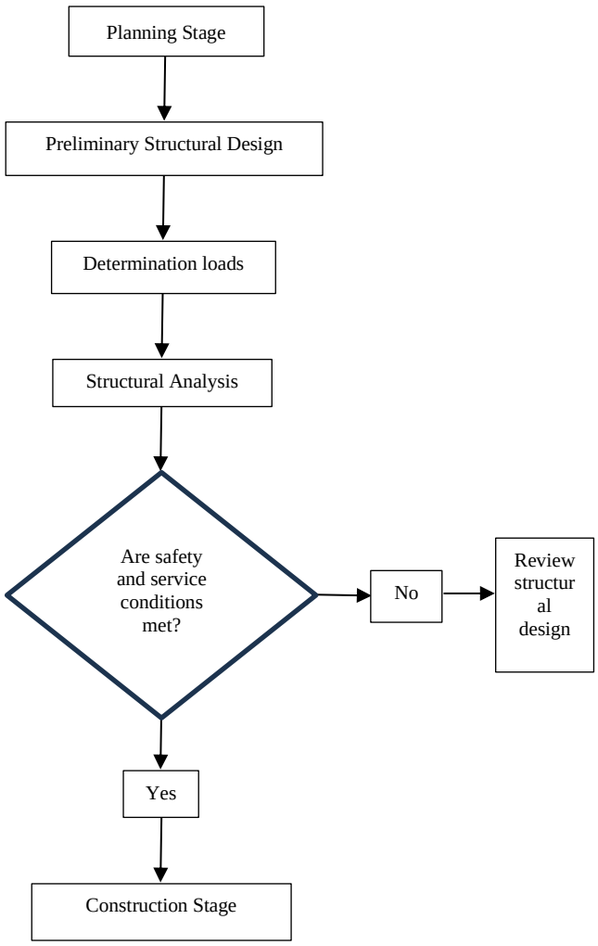


Figure 1
Stages of structural design

Source: adopted from (Kassimali, 2015).

- **Planning Stage**. The planning phase usually involves the establishment of the functional requirements of the proposed structure, the general layout and dimensions of the structure, general considerations of the possible types of structures (e.g., rigid frames or trusses) that may be used, and the types of materials to be used (e.g., structural steel or reinforced concrete).

This stage may also take into account other considerations of non-structural factors, such as aesthetic aspects, environmental impact of the structure and some others.

Its result is generally a structural system that meets the functionality requirements and is expected to be the most economical. This stage is perhaps the most crucial of the entire project and requires experience and knowledge of construction practices, as well as a thorough understanding of the behaviour of structures.

- **Preliminary structural design.** In the preliminary structural design stage, the size of the structural system elements selected in the planning stage is estimated based on an approximate analysis, previous experience and code or regulation requirements. Thus, the sizes of the selected elements are used in the next stage to calculate the weight of the structure.

- **Determination of loads.** Load estimation involves the determination of all loads that can be expected to act on the structure.

- **Structural analysis.** In the structural analysis, the load values are used to develop an analysis to determine the resulting stresses in the elements and the deflections at different points of the structure.

- **Safety and serviceability check.** The results of the analysis are used to determine whether or not a structure meets the safety and serviceability requirements of the design code. If these requirements are satisfied, then the design drawings and construction specifications are executed and the construction phase begins.

- **Structural design review.** If the requirements of the structure are not satisfied, then the element sizes are reviewed, and phases 3 to 5 are repeated until all safety and serviceability requirements are met (Kassimali, 2015).

Mathematical model FEM

Different problems treated in science and engineering are often described in terms of differential equations, formulated by using continuous mechanics models.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Betanzos-Castillo, Francisco, Fuentes-Castañeda, Pilar and Cortez-Solis, Reynaldo. [2024]. Structural analysis of a lifting platform for autonomous vertical vehicular parking. Journal of Architecture and Design. 8[19]-1-8: e10819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

In general, elasticity problems are reduced to solving the differential equations, known as equilibrium equations together with stress-strain relations or the strain-displacement relations and the compatibility equation under given boundary conditions.

Equilibrium equations in an elastic body in two dimensions:

$$\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + F_x = 0 \quad [1]$$

$$\frac{\partial \tau_{yx}}{\partial x} + \frac{\partial \sigma_y}{\partial y} + F_y = 0 \quad [2]$$

Where σ_x and σ_y are normal forces in the *x* and *y* axes respectively, τ_{xy} and τ_{yx} are shear forces acting in the xy plane.

The strain-displacement relationships are:

$$\varepsilon_x = \frac{\partial u}{\partial x} \quad [3]$$

$$\varepsilon_y = \frac{\partial v}{\partial y} \quad [4]$$

$$\gamma_{xy} = \frac{\partial v}{\partial x} + \frac{\partial u}{\partial y} \quad [5]$$

Where $\varepsilon_x$and ε_y are the normal deformations in the *x*- and *y*-axis directions respectively, the engineering shear deformation in the *xy* plane is γ_{xy}; *u* and *v* are infinitesimal displacements in the *x*- and *y*-axis directions respectively.

Constitutive equations (stress-strain relationships). These relationships describe the state of deformation, deformations induced by internal forces or stresses resisting against applied loads. These relationships depend on the material properties, they are determined experimentally. Hooke's law relates six components of the three-dimensional stress tensors to the strain tensors, as follows:

$$\sigma_x = \frac{vE}{(1+v)(1-2v)} e_v + 2G\varepsilon_x \quad [6]$$

$$\sigma_y = \frac{vE}{(1+v)(1-2v)} e_v + 2G\varepsilon_y \quad [7]$$

$$\sigma_z = \frac{vE}{(1+v)(1-2v)} e_v + 2G\varepsilon_z \quad [8]$$

$$\tau_{xy} = G\gamma_{xy} = \frac{E}{2(1+v)}\gamma_{xy} \quad [9]$$

$$\tau_{yz} = G\gamma_{yz} = \frac{E}{2(1+v)}\gamma_{yz} \quad [10]$$

$$\tau_{xz} = G\gamma_{zx} = \frac{E}{2(1+v)}\gamma_{zx} \quad [11]$$

Or inversely:

$$\varepsilon_x = \frac{1}{E}\left[\sigma_x - v(\sigma_y + \sigma_z)\right] \quad [12]$$

$$\varepsilon_y = \frac{1}{E}\left[\sigma_y - v(\sigma_z + \sigma_x)\right] \quad [13]$$

$$\varepsilon_z = \frac{1}{E}\left[\sigma_z - v(\sigma_x + \sigma_y)\right] \quad [14]$$

$$\gamma_{xy} = \frac{\tau_{xy}}{G} \quad [15]$$

$$\gamma_{yz} = \frac{\tau_{yz}}{G} \quad [16]$$

$$\gamma_{zx} = \frac{\tau_{zx}}{G} \quad [17]$$

Where E is Young's modulus, v is Poisson's ratio, G is the shear modulus and e_v the volumetric strain expressed by the sum of the three normal strain components, $e_v = \varepsilon_x + \varepsilon_y + \varepsilon_z$.

The FEM assumes an object of analysis as a set of elements having arbitrary shapes and finite sizes (called finite element), approximates partial differential equations by simultaneous algebraic equations and numerically solves various elasticity problems (Nakasone, Yoshimoto, & Stolarski, 2006).

The Finite Element Analysis method requires the following main steps:

- Discretization of the domain into a finite number of subdomains (elements).
- Selection of interpolation functions.
- Development of the elementary matrix for the subdomain (element).
- Assembly of the elementary matrices of each subdomain to obtain the global matrix of the complete domain.
- Imposition of the boundary conditions.
- Solution of the equations.
- Additional calculations (if required).

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Betanzos-Castillo, Francisco, Fuentes-Castañeda, Pilar and Cortez-Solis, Reynaldo. [2024]. Structural analysis of a lifting platform for autonomous vertical vehicular parking. Journal of Architecture and Design. 8[19]-1-8: e10819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

The ability to discretize irregular domains with finite elements makes the (FEA) method a valuable and practical analysis tool for the solution of boundary, initial and eigenvalue problems arising in different engineering disciplines (Madenci & Guven, 2015).

Computational Model

Simulation programs, over time, have improved their analysis, using improvements in the meshing processes, acceptance criteria, implementation of variables and presentation of results, where it is absolutely essential that the user acquires skills and can identify its operation, to have a command of the software (Díaz Iglesias, 2021).

In order to perform simulation and structural analysis, some design software is used, such as: Ansys Workbench® which is an engineering simulation software, provides a wide range of tools and resources for post-processing and visualization of simulation results, allowing to understand and analyze the results effectively (SEMCOCAD, 2024); on the other hand, SOLIDWORKS® is a 3D CAD design software, offers solutions to cover the aspects involved in the product development process from creating, designing, simulating, manufacturing, publishing and managing the data of the design process (SOLIDBI, 2024).

Results

To obtain the structural behaviour of the lifting platform, where the vehicles will be housed and later transferred to their final available location, a bridge type structure was designed, without lateral perforations, square profile 127 mm per side, 12.7 mm thick, 25.4 mm plate, upper and lower central part without plate and lower sides without plate, see figure 2. The creation of the platform geometry was carried out in SOLIDWORKS® and Ansys Workbench®. The geometry consists of the generation of sketches, drawings, 3D operations such as extrusion, enclosure, to mention a few operations.

Simulation in SolidWorks

To determine the structural behavior of the lifting platform model, a load distributed along the entire structure was configured. Figure 3 shows the resulting Von Mises stresses, with a minimum of 4.385e-03 MPa and a maximum of 7.571e-03 MPa.

On the other hand, later during post-processing, the total deformation of the structure was determined, which are 1e-3 mm as minimum and 2.65e+0 mm as maximum. This can be seen in Figure 4.

Box 2

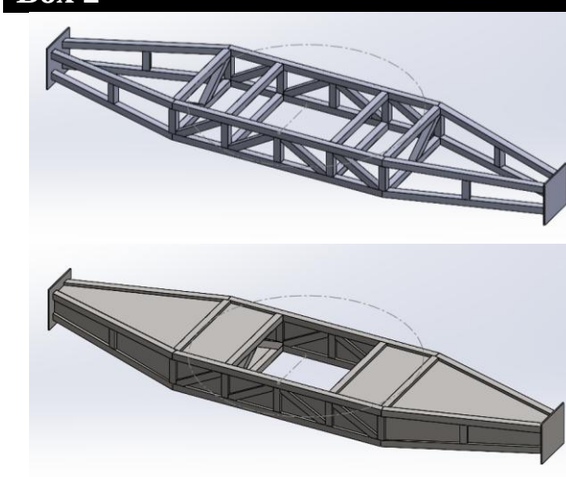


Figure 2
Computational model

Source: Own elaboration

Box 3

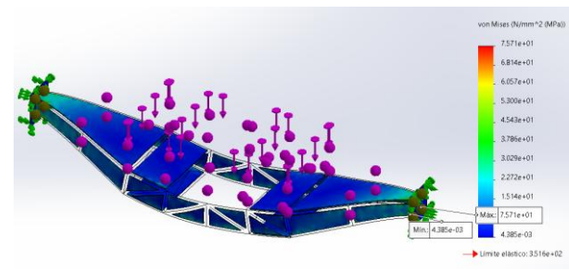


Figure 3
Von Mises forces

Source: Own elaboration

Box 4

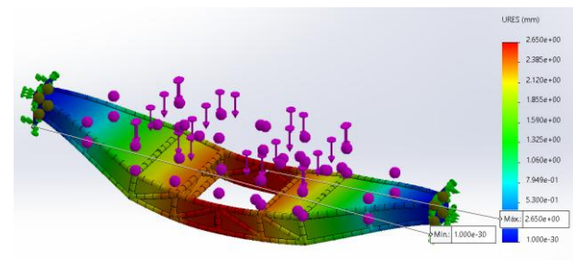


Figure 4
Total deformation

Source: Own elaboration

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Betanzos-Castillo, Francisco, Fuentes-Castañeda, Pilar and Cortez-Solis, Reynaldo. [2024]. Structural analysis of a lifting platform for autonomous vertical vehicular parking. Journal of Architecture and Design. 8[19]-1-8: e10819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

Simulation in Ansys Workbench

To translate the behaviour from a physical model to a computational model, the problem must be understood, which leads to obtaining an analytical solution using the theory of simple stresses and stress concentration factors. The computational model of the platform for an autonomous vertical parking was designed in DesignModeler of Ansys Workbench, considering the geometry, load, boundary conditions and structural materials, in this case a PTR AISI 1010 material was used, square profile 127 mm per side, 12.7 mm thick, 25.4 mm plate, upper and lower central part without plate and lower sides without plate and derived from the symmetry conditions, an axisymmetric analytical analysis was performed, see figure 5.

In Figure 6, using the Static Structural module of Ansys Workbench 2024 R1 Student software, which was configured to use AISI 1010 structural steel for the proposed computational model, the static structural analysis of the elevation platform supporting the parking transfer was performed, which allowed determining the total deformation and equivalent stress.

Box 5

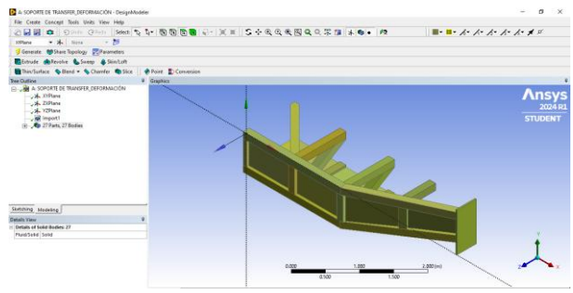


Figure 5
Axisymmetric geometry of the support structure

Source: Own elaboration

Box 6

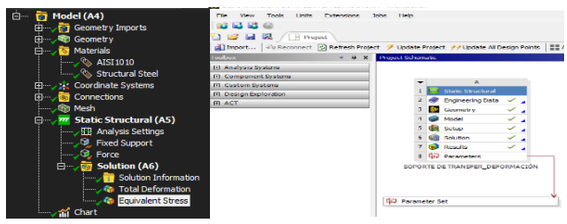


Figure 6
Configuration for static structural analysis simulation

Source: Own elaboration

Derived from the geometry of the computational model, an axisymmetric cut was made in Ansys, then the meshing was performed, with a mesh configuration for a type of mechanical analysis; it has 67086 elements and 1406 elements, being a discretization by triangular polygons to perform the configured analysis, this is shown in Figure 7.

Box 7

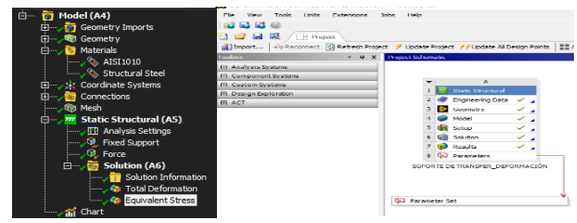


Figure 7
Discretization of mechanical type meshing

Source: Own elaboration

For the static structural analysis, an input force of 49033 N was used on 6 faces of the structure shown in red in Figure 8. According to the configurations made in the Ansys Workbench software, it can be observed that the platform structure presented deformation according to the colour code with a minimum value of 0 and a maximum value of 2.0223e-002 mm, as shown in Figure 9.

Box 8

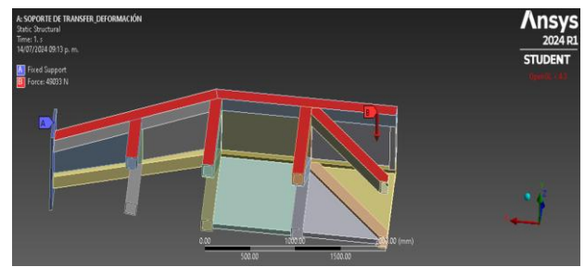


Figure 8
Configuration of forces and supports

Source: Own elaboration

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Betanzos-Castillo, Francisco, Fuentes-Castañeda, Pilar and Cortez-Solis, Reynaldo. [2024]. Structural analysis of a lifting platform for autonomous vertical vehicular parking. Journal of Architecture and Design. 8[19]-1-8: e10819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

Box 9

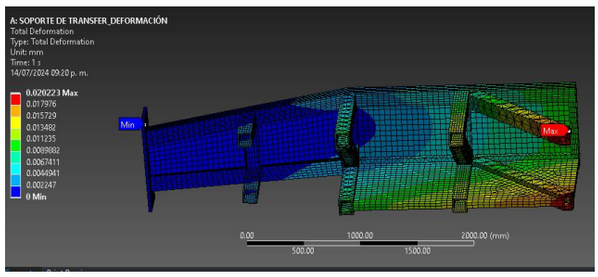


Figure 9
Minimum and maximum total deformation

Source: Own elaboration

Finally, Figure 10 shows the minimum and maximum equivalent stress values, i.e., using the Von Mises criterion, these were 0 MPa and 199.62 MPa, respectively, which are located at the end of the fastening element of the support structure of the lifting platform.

Box 10

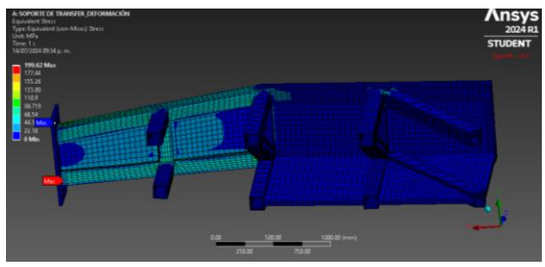


Figure 10
Equivalent (von-Mises) Stress

Source: Own elaboration

Discussion of results

The stress distribution and total deformation were determined numerically using the finite element technique, this type of analysis is very suitable for structural analysis, which allowed to determine the mechanical behaviour of a lifting platform that as a conceptual proposal will be used for an autonomous vertical parking with a vision towards Industry 4.0. In addition, this technique saves time and money in performing strength of materials calculations, as well as in the construction and prototyping of physical models.

The computational model represents and describes the total deformation and the equivalent stress when subjected to equivalent loads, making it possible to visualize the structural behaviour under different working and boundary conditions, which gives an idea of how such behaviour would be in reality and saves time and money.

The results of the present investigation indicate that it is feasible to use computational models with the help of CAD software, which allows with a certain relative ease to perform various simulations emulating with this the real physical conditions of this type of mechanical elements, as well as the comparison of the results obtained, so it is recommended to continue working on this line and take advantage of the benefits of these tools as support for research in the engineering area.

Conclusions

The present study demonstrated the potential of the finite element technique for similar physical phenomena in the area of strength of materials, since it allowed the numerical calculation of the total deformation and equivalent stresses (von Mises) by using two CAD software. This simulation will allow to extrapolate the results of real working considerations, since it is observed that both software have a greater potential, the results obtained are very similar, which undoubtedly will allow to analyze different scenarios of application.

Future work should be directed towards the study of new conceptual designs and make the comparison with theoretical calculations in order to optimize the results and resources. In this way, it will be possible to predict the behavior of the lifting platform in different materials subjected to different working conditions.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

The contribution of each researcher in each of the points developed in this research, was defined based on:

Betanzos-Castillo, Francisco: Contributed to the project idea, research method and technique.

Fuentes-Castañeda, Pilar: wrote the manuscript with input from all authors and developed the theoretical formalism.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Betanzos-Castillo, Francisco, Fuentes-Castañeda, Pilar and Cortez-Solis, Reynaldo. [2024]. Structural analysis of a lifting platform for autonomous vertical vehicular parking. Journal of Architecture and Design. 8[19]-1-8: e10819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

Cortez-Solis, Reynaldo: designed the model and the computational framework and analyzed the data.

Availability of data and materials

There are no data available.

Funding

The research did not receive funding, although it has received support from the Tecnológico Nacional de México - TES Valle de Bravo in terms of technical support.

Acknowledgements

Special thanks to the Tecnológico Nacional de México - TES Valle de Bravo, since their support has allowed the development of this project, important stages have been achieved that lead to an advance in technological development and in the training of human resources.

References

Basics

Díaz Iglesias, C. A. (11 de 08 de 2021). Repositorio Insitucional Universidad Distrital Francisco de Jose Caldas. Obtenido de repository.

SEMCOCAD. (19 de 05 de 2024). Soluciones y capacitación CAD/BIM. Obtenido de SEMCOCAD:

SOLIDBI. (19 de 05 de 2024). SOLIDBI-Inspira tu innovación.

J.C.TORRES. (1998). Google Académico.

Kassimali, A. (2015). Análisis Estructural. Cengage Learning. ISBN: 978-1-133-94389-1

Rodríguez A. G. y Ramos J. L. (2009). Renovación urbana del Centro Histórico de Barranquilla: orígenes y evolución del proceso. Revista Digital de Historia y Arqueología desde el Caribe, 11: 46-62.

Rodríguez, F. D. (2019). Academia.edu. Obtenido de Google Academico.

Supports

Galán Ávila, J. A., Avendaño Rodríguez, D. F., & Villalobos Correa, D. E. (2022). Design and simulation of mechanical press for testing of coining tools with nanostructured coatings. Revista Facultad de Ingeniería Universidad de Antioquía(104), 53-70.

Halicioglu, R., Canan Dulger , L., & Tolga Bozdana, A. (2016). Structural design and analysis of a servo crank press. Engineering Science and Technology, an International Journal, 19, 2060-2072.

Madenci, E., & Guven, I. (2015). The Finite Element Method and Applications in Engineering Using ANSYS. New York: Springer.

Nakasone, Y., Yoshimoto, S., & Stolarski, T. (2006). Engineering Analysis with ANSYS Software. Oxford: Elsevier.

Differences

Oguz Örmecioglu, T., Aydogdu, Í., & Tugba Örmecioglu, H. (2024). GPU-based parallel programming for FEM analysis in the optimization of steel frames. Journal of Asian Architecture and Buikding Engineering, 1-22.

Rameshrao Yawale, V., & Nivrutti Naik, N. (2021). Static structural and modal analysis of mechanical component using FEA approach. International Journal of Creative Research Thoughts, 9, 4003-4012.

Yixu Chu, Junying Lin, Kun Li. Design and Simulation of Foldable Wing eVTOL UAV. Academic Journal of Engineering and Technology Science (2024) Vol. 7, Issue 4: 136-143.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Journal of Architecture and Design 8[19]1-13: e20819111
Article

5'S diagnosis in the substation department of the western transmission area

Diagnóstico de 5'S en el departamento de subestaciones de la zona de transmisión poniente

Serrano-González, Sergio*[a], Maturano-Maturano, Benito Armando[b], Castellanos-López, Liliana Yadira[c] and Alvarado-Reséndiz, José Luis[d]

[a] Tecnológico Nacional de México Campus Occidente del Estado de Hidalgo • HNS-96707-2023 • 0000-0003-0252-1259 • 1004108
[b] Tecnológico Nacional de México Campus Occidente del Estado de Hidalgo • KYR-9203-2024 • 0000-0001-6250-6339 • 1015555
[c] Tecnológico Nacional de México Campus Occidente del Estado de Hidalgo • KZT-9082-2024 • 0009-0000-7531-3851 • 2036637
[d] Universidad Autónoma del Estado de Hidalgo • LBH-9354-2024 • 0000-0003-1473-7727 • 1288405

CONAHCYT classification:

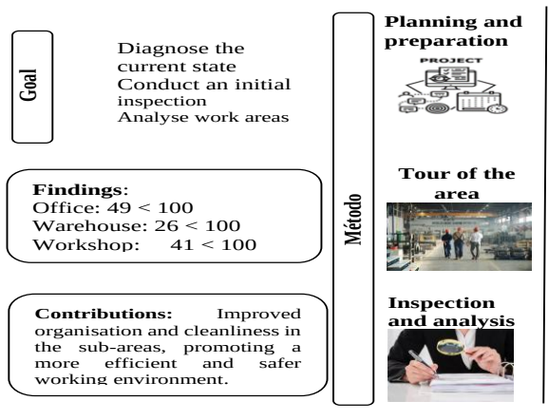
Area: Engineering
Field: Engineering
Discipline: Industrial engineer
Subdiscipline: Control and measurement of productive processes

https://doi.org/10.35429/JAD.2024.8.19.1.11
History of the article:
Received: January 19, 2024
Accepted: December 31, 2024

* ✉ [sserrano@itsoeh.edu.mx]

Abstract

In the Western Transmission Zone, the current state of the 5S methodology was assessed in the substation department, covering offices, workshop and warehouse, due to delays caused by inefficient search for tools and documents. The level of 5S implementation was diagnosed, resulting in low scores: Offices 49/100, Warehouse 26/100 and Workshop 41/100, which showed poor organisation. It is recommended to apply the 5S methodology to improve efficiency and safety by eliminating unnecessary objects, maintaining cleanliness and encouraging this habit to increase productivity and competitiveness without additional costs.



Implementation, 5S Methodology, Efficiency

Resumen

En la Zona de Transmisión Poniente, se evaluó el estado actual de la metodología 5S en el departamento de subestaciones, abarcando oficinas, taller y almacén, debido a los retrasos causados por la búsqueda ineficiente de herramientas y documentos. Se diagnosticó el nivel de implementación de las 5S, resultando en puntuaciones bajas: Oficinas 49/100, Almacén 26/100 y Taller 41/100, lo que evidenció una deficiente organización. Se recomienda aplicar la metodología 5S para mejorar la eficiencia y seguridad, eliminando objetos innecesarios, manteniendo la limpieza y fomentando este hábito para aumentar la productividad y competitividad sin costos adicionales.

Implementación, Metodología 5S, Eficiencia

Citation: Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.

Introduction

The 5S methodology refers to five Japanese words (Seiri, Seiton, Seiso, Seiketsu and Shitsuke), first the selection of necessary and not necessary materials, second the order of all necessary elements, third cleanliness in furniture and facilities, fourth standardisation of the first stages and fifth discipline to be taken by the workers as the main problem detected in the industry, In particular, in the substation department of the Western Transmission Zone belonging to the Federal Electricity Commission, the lack of habits of order, cleanliness and the lack of commitment of the workers, conditions that cause low productivity and poor quality in the service provided.

With the diagnosis of the 5S methodology, it was identified where to reduce the response time to failures that require corrective maintenance, in addition to proposing scheduled daily activities through the organisation of tools, equipment, materials and information (folders, manuals, diagrams, plans, etc.), which can be consulted efficiently, reducing search times and the elimination of unnecessary activities that affect the operation process.

In the search for and elimination of unnecessary activities, the 5S methodology was used, which is part of the techniques of the Production Management System or Lean Manufacturing, because the process and results of continuous improvement depend on the leadership of top management and the commitment of all the organisation's staff (Piñero, Vivas, & Flores, 2018). For their part, Fernández E., Avella, and Fernández M. (2020), state that these are five steps that are implemented gradually, in order to create an attitude of respect in the members of the organisation to properly maintain their workplace, according to Aldavert, Vidal, and Lorente (2018), point out that the 5S aim to make agile changes through visual control and standardisation of resources, obtaining benefits such as minimising waste, increasing quality, productivity, efficiency, where the participation of the entire organisation is essential.

Taking into account Lay-De-León et al. (2022), in the application of Lean Manufacturing and its 5S technique, it promotes the interest of workers, bringing with it the increase of productivity and competitiveness. The 5S is focused on achieving order and cleanliness in all areas of the company, creating a discipline that eventually becomes a culture and common practice.

The implementation of the 5‘s methodology for continuous improvement in work processes has been a topic of interest for Huamán and Rodríguez (2021) in their thesis demonstrating that, the application of the 5’s methodology improved overall efficiency from 32.27% to 74.78%, reducing waiting times in the dispatch process, saving a total time of 38.65 hours per person for 60 days.

Vargas and Camero (2021) present the application of kaizen and 5S in a manufacturing company with productivity problems for 4 consecutive years in the production area of aqueous adhesives, while Luna, et. al. (2020) propose an improvement plan based on 5S to increase productivity and reduce workplace accidents, stipulating that, after the application of this methodology, a safer and more efficient working environment is created, with workers committed to producing quality products.

The implementation of 5S, in the work of Arroba (2022), indicates that it had a positive impact, thanks to the order of inputs and tools, there was a favourable increase in productivity of 64% in the production of rolls, in addition to allowing the application of improvements for all staff, preserving their safety and ensuring the quality of their products, therefore the application of 5S leads to the implementation of Lean Manufacturing which is a philosophy of Japanese origin responsible for eliminating activities called ‘dumb’ that do not add value through the use of tools and methodologies; while Socconini (2019), defines Lean Manufacturing as, "a continuous and systematic process of identifying and eliminating waste or excess".

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

With the elimination of waste, costs are reduced by optimising processes and increasing productivity, improving the quality of products, from the point of view of Vinodh (2022), the purpose of Lean Manufacturing is to eliminate waste, streamline processes and improve value addition, based on the kaizen philosophy of standardising work processes and sustaining the improvements achieved (p.3), according to (Muñoz et al. 2022), they point out that, the main objective of the Lean philosophy is to increase the productivity, efficiency, competitiveness and profitability of companies (p.13), citing Tapia et al. (2017), rejects, failures and defects originate from the identification of non-conformities or from customer returns derived from products that do not meet optimal quality conditions and that must be reprocessed or destroyed (p. 172). To this end, overproduction that is not adjusted to demand must be avoided, reducing waiting time for industries implies costs by having downtime in the stages of a process manifested in waiting for material, information, tools, machinery, maintenance, excess production, material supply time, etc., (Muñoz et al. 2022, p. 26-27).

Similarly the application of Kaizen methodology involves a system of continuous improvement in all aspects, being a tool that contributes to the elimination of waste, according to Suarez (2015), states that Kaizen is a comprehensive philosophy, which seeks to improve daily activities, from work processes to the individual (p.20), seen in another way Demirbaş, Blackburn, and Bennett (2020), argues that some of the key objectives of Kaizen include quality control, just-in-time delivery, standardised work, use of efficient equipment and elimination of waste (p.5 For this purpose, a Gemba Walk should be used, which consists of a walk through all areas of a company, in which Cause-Effect diagrams are made, which is a graphical representation of causes that produce a specific problem, as well as a check sheet, which is a quality tool used for inspection and audits.

The Kaizen methodology from the approach of Boero (2020), describes it as a graphic representation of all the possible causes of a phenomenon, generally presented in the form of the backbone of a fish on a central axis directed to the effect and on the same axis placing the causes, to end with a SWOT matrix is a tool for study and analysis applicable to companies, products, individuals, etc., its name derives from the external factors and internal factors. According to the perspective of Castillo and Banguera (2018), they point out that the main objective of applying the SWOT matrix is to provide a diagnosis to make strategic decisions and improve in the future.

The research shows that the implementation of the 5S methodology improves efficiency by optimising the search for the elements necessary for the development of maintenance and operation activities, creating comfortable and safe work spaces for all members of the substation department of CFE's Western Transmission Zone. By means of objectives that will make it possible to measure: Diagnose the current state of the 5S methodology, to identify areas for improvement and propose corrective actions in the maintenance and operation activities of the electrical power substations belonging to the Western Transmission Zone of the Federal Electricity Commission (CFE).

Diagnosing the current state begins with an initial inspection to analyse the current state of order and cleanliness of the substation department, identifying the sub-areas to be worked on, and analysing the work areas by means of an inspection checklist to determine the degree of organisation and cleanliness of each area.

Methodology

The research is characterised as a mixed methodology, dedicated to collecting, analysing and integrating both quantitative and qualitative research, and from the perspective of Rojas (2023), the mixed method collects information of a quantitative and qualitative nature, using technical mechanisms of these two approaches, where methodological plurality prevails (p. 137).

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

The research design is related to the methods and techniques combined for the solution of the problem, reason that leads to the research the use of the field design, having as objective the compilation of data from the place of origin, besides being directly related to the applied methodological procedure 5S, citing Rojas (2023), states that in the field designs the data of interest are collected directly from reality, that is, from the empirical experience, and that they are the product of the research without any interruption (p. 140).

According to Corbetta (2023), this method is based on the collection of information by means of questions to the individuals who are the object of research, which form a representative sample, made up of two fundamental parts: questions and answers that, in a standardised way, are known as questionnaires (p. 204).

Planning and preparation

The survey applied to the staff (see Annex I), consists of a questionnaire of 8 closed questions, in which the knowledge of the 5S was raised. The qualitative data collection was carried out using the technique based on direct observation, taking into account Corbetta (2023), who states that through observation the researcher studies a given social phenomenon, first participating in it, in order to experience it and be able to offer a description of it (p. 302). In the execution of the project, direct observation was applied when carrying out a tour of the three sub-areas: offices, warehouse and workshop, with the support of tools such as Gemba Walk and a checklist format prepared according to the needs of each of the sub-areas.

The application of surveys, collected important data related to the 5S methodology, one of relevance is that 67% of workers have knowledge of the 5S, an advantage to promote its application, however, 14 of the 18 workers indicate that their workplace is not commonly kept clean and tidy, ie. 78% do not meet the requirements of order and cleanliness, implying delays in performing their maintenance activities and operation of different substations, in addition to risks to their safety by falls, blows, etc.

Which indicates that the 5S methodology is not being applied, 78% do not comply with the requirements of order and cleanliness, implying delays when carrying out their maintenance and operation activities in the different substations, as well as safety risks due to falls, blows, etc., which indicates that the application of the methodology is substantial to improve their work space and productivity.

Tour of the area

The diagnosis began with a walk and direct observation of the substation department in three sub-areas: offices, warehouse and workshop (see table 1), where the Gemba Walk tool was applied to gather information and comments on the sub-areas under study.

Box 1

Table 1
Gemba Walk checklist

CFE Comisión Federal de Electricidad	COMISIÓN FEDERAL DE ELECTRICIDAD
	WESTERN TRANSMISSION AREA
GEMBA WALK CHECKLIST	1 0F 2
Walking area: Office and Workshop	
Walkabout participants: Work team	
A. Purpose of the walk (why do it): To identify the most vulnerable areas in terms of tidiness and cleanliness.	
B. Initial conditions observed in the area (strengths to reinforce opportunities for improvement): Documents are on top of the work area (office). Tools and/or work equipment are not in a specific place. Lack of cleanliness in work areas Lack of signposting in the work area	
C. Notes for pre-walk review with area leader and other walkers None	
D. Key questions during the walk (Turn the back of the card)	
E. Follow-up actions. Application of 5's checklists in each of the areas (office and workshop).	

Table 2 shows that tools, equipment and documents do not have a specific place, and unnecessary objects were found obstructing the work space in the three sub-areas. After detecting the problems in the substation department, it was determined that the lack of organisation and cleanliness is the main factor to be solved.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

Box 2

Table 2

Gemba Walk checklist

CFE Comisión Federal de Electricidad	COMISIÓN FEDERAL DE ELECTRICIDAD WESTERN TRANSMISSION AREA	
	GEMBA WALK CHECKLIST	2 OF 2
D. Key questions during the walk **1. How are things in general? Normal workflow, safety for all staff, punctuality, productivity.** **2. HMMEL conditions** **Tools: There is no classification of tools, plus they are not in a fixed locationTools: There is no classification of tools, plus they are not in a fixed location.** **Material: The material is untidy, unsorted, and it is difficult for workers to find it efficiently.** **Manpower: Manpower is good, however, the tools are not in a specific place, which prevents the work flow from being more efficient.** **Equipment: Equipment is a bit dirty and with unnecessary objects around it.** **Safety: Personal protective equipment is not complete.** **Space: The workshop does not have a defined area, there are objects obstructing the way.**		
Key areas, customers, suppliers. The work carried out is of high quality		
What to maintain to start with? Start with small habits of cleanliness and organisation.		

Note: A Gemba Walk format was presented on the collection of information, based on direct observation in each of the sub-areas of the substation department.

Once the problems had been detected, an Ishikawa diagram was drawn up showing the possible causes based on the analysis of five critical factors: machinery, labour, method, material and environment; the lack of culture is one of the aspects that must be modified to improve conditions and increase efficiency in the work processes.

Box 3

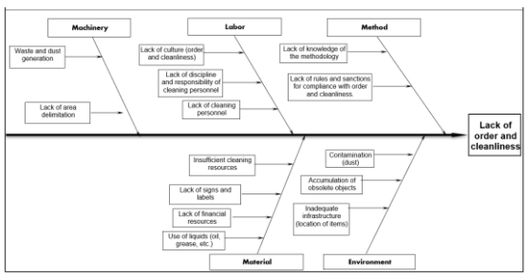


Figure 1

Figure 1 Cause-effect diagram: Lack of order and cleanliness

Figure 1 shows the analysis of the Ishikawa diagram, which shows that the workers do not have a comfortable work space, due to a lack of hygiene habits, when they carry out maintenance activities they use various products that generate solid waste on floors, work tables, etc., and are not disposed of correctly, another cause of disorder is the accumulation of documents and obsolete objects.

Another cause of disorder is the accumulation of documents and obsolete objects; a critical factor identified is the lack of signage and delimitation of work stations, it is necessary to relocate various equipment, machinery and tools, as well as using colours on the floors as visual aids, for the safety of all staff.

Stage 1: Seiri (Select)

In the 'Seiri' stage (see figure 2), photographs were taken of the sub-areas: offices, warehouse and workshop, in order to establish the beginning of the methodology, where the lack of order and cleanliness is demonstrated.

Box 4

Figure 2

Offices, warehouse and substation workshop

Initial inspection and analysis

To determine the level of compliance with the 5S methodology, an initial inspection was carried out by applying a checklist to control compliance with the order and cleanliness requirements of the substation department to be evaluated (see table 3), which shows the checklist applied in the office sub-area, and the checklists for the warehouse and substation workshop sub-areas are shown in annexes 2 and 3; These forms show the different items and the ordinal scale for evaluation, which ranges from 4 to 0 points, with the rating being given according to the attributes observed for each site, with the answers being related to the characteristics of each item: excellent= 4 points, good= 3 points, regular= 2 points, insufficient= 1 point and does not comply= 0 points, this being the lowest rating.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

Box 5

Table 3

Check list inspection inicial 5S: offices

5'S AUDIT CHECKLIST				
COMISIÓN FEDERAL DE ELECTRICIDAD				
NORTHERN TRANSMISSION ZONE: Substation Department				
Evaluation date: 24 July 2023			**Objective:** To implement the 5's methodology to improve the efficiency of maintenance and operation processes in the substation department of the Western Transmission Zone of the Federal Electricity Commission.	
Assessor: 1				
Area: Offices			***Weightings***	
			4	Excellent
			3	Good
			2	Regular
			1	Insufficient
			0	Does not comply

Aspects to verify		*No.*	*Descriptionn*	*Score*	*Remarks*
1. SERI (SELECT)	Differentiate between what is necessary and what is unnecessary	1.1	Tools and work equipment are tidy, in the assigned place, identified and clean.	1	The tools do not have a specific location, so it takes longer to carry out their programmed activities.
		1.2	There is a clear identification of unsafe conditions in the area, equipment and operations.	2	
		1.3	The walkways and common areas are free for pedestrians and vehicles.	2	
		1.4	There are unclassified tools or equipment for the execution of the activities.	1	
		1.5	Unnecessary broken / unserviceable items, or items from another process (tools, equipment, PPE) are separated or identified.	2	
			Maximum score:	20	
			Total:	8	

Aspectos a verificar		*No.*	*Descripción*	*Puntaje*	*Observaciones*
2. SEITON (ORGANISE)	Ordering of items, establishing a specific location	2.1	There are demarcation lines for access, circulation, etc. (There are signs and delimitation of areas).	3	Folders are not organised, it is difficult to identify documents, there are obsolete documents on the desk.
		2.2	Documents and folders are identified with dividers or marked with acronyms, and are filed under a consecutive number.	1	
		2.3	Documents, equipment and tools have a fixed location and are always in place.	1	
		2.4	There are objects that are not necessary for the development of the area's activities.	1	
		2.5	The distribution of items (tools, equipment, etc.) is adequate.	1	
			Maximum score:	20	
			Total:	7	

Aspects to verify		*No.*	*Descriptionn*	*Score*	*Remarks*
3. SESO (CLEANING)	Eliminating dirt and avoiding soiling	3.1	The area is free of dust and dirt (computers, desks, tables, etc.).	1	The department has cleaning supplies, however, there are areas that are not adequately cleaned.
		3.2	Waste containers, which are regularly emptied without exceeding their capacity.	2	
		3.3	The floor of the work area is clean and free of obstacles that could cause falls from the same level.	2	
		3.4	Cleaning is carried out as scheduled in the cleaning plan, and is inspected by a person responsible for the area.	3	
		3.5	The necessary cleaning material is available and accessible.	4	
			Maximum score:	20	
			Total:	12	

Aspects to verify		*No.*	*Descriptionn*	*Score*	*Remarks*
4. SEIKETSU (STANDARDISE)	Getting the first 3's implemented	4.1	Cleaning standards are complied with and checked that they are correctly applied.	1	The office area does not comply with the level of order and cleanliness, and there are no regulations within the substation department to control order and cleanliness.
		4.2	Resources for cleaning and work organisation are provided.	3	
		4.3	Personnel wear personal protective equipment that is clean and in good condition.	3	
		4.4	Desks, tables, computers, etc., are kept clean and in good condition.	2	
		4.5	Cleanliness, control and tidiness records are kept.	2	
			Maximum score:	20	
			Total:	11	

Aspects to verify		*No.*	*Descriptionn*	*Score*	*Remarks*
5.SHITSUKE (DISCIPLINE)	Make the 5'S activities a habit.	5.1	All personnel collaborate in the cleaning tasks (they comply with the existing rules related to keeping the workplace in complete order, cleanliness and cleanliness).	1	It is observed that the personnel do not adequately apply the 5's, however, they are willing to collaborate to improve the conditions in their work areas.
		5.2	The workstation is delivered and received in optimal conditions: clean and tidy.	3	
		5.3	Inappropriate use of the facilities (disorder) is reported to the person in charge of the area.	3	
		5.4	Signage is respected throughout the facility.	2	
		5.5	All employees eat, smoke or drink only in the areas designated for this purpose.	2	
			Maximum score:	20	
			Total:	11	

The application of the 5S verification format, see table 3, shows that the office sub-area mainly lacks order, pointing out the lack of hygiene in bookshelves and desks, in addition to the items identified that are alien to the process and that make access to documents, tools and other items difficult.

Results

Offices

The following are the initial results after the application of the checklist within the sub-areas in which there are various deficiencies in order and cleanliness.

Box 6

Table 4

Initial inspection results: offices

COMISIÓN FEDERAL DE ELECTRICIDAD			
WESTERN TRANSMISSION AREA			
Department (Criterion): SUBSTATIONS			
Results Initial inspection 5'S methodology			
24 July 2023	**Area: Offices**		
Result	**Goal**	**Real**	**Percentage %**
Selection	20	8	**40%**
Order	20	7	**35%**
Cleanliness	20	12	**60%**
Standardisation	20	11	**55%**
Discipline	20	11	**55%**
General	**100**	**49**	**49%**

Colour coding	
81 - 100	Outstanding! Strong 5S culture in place
60 - 80	Strong 5S implementation but room for improvement
< 60	Significant potential for improvement

Table 4 shows that in the office sub-area 49 points were obtained, order was the most critical factor due to the fact that documents do not have a specific folder and area, causing time delays, followed by the selection of items.

Warehouse

The warehouse is the most serious sub-area in terms of 5S compliance (see table 5), where it is indicated that order and cleanliness are the points affected because, folders of documents, tools and equipment that are kept in this area do not have an established (fixed) place, there are no signs and there is a lack of a cleaning programme.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

Box 7

Table 5
Initial inspection results: warehouse

COMISIÓN FEDERAL DE ELECTRICIDAD			
WESTERN TRANSMISSION AREA			
Department (Criterion): SUBSTATIONS			
Results Initial inspection 5'S methodology			
24 July 2023	Area: Substation Department Warehouse		
Result	**Goal**	**Real**	**Percentage %**
Selection	20	5	**25%**
Order	20	3	**15%**
Cleanliness	20	4	**20%**
Standardisation	20	8	**40%**
Discipline	20	6	**30%**
General	**100**	**26**	**26%**
Colour coding			
81 - 100	Outstanding! Strong 5S culture in place		
60 - 80	Strong 5S implementation but room for improvement		
< 60	Significant potential for improvement		

In Table 5, an overall score of 26 points was obtained, stating that the implementation of 5S should be taken as a routine to maintain safety in the area.

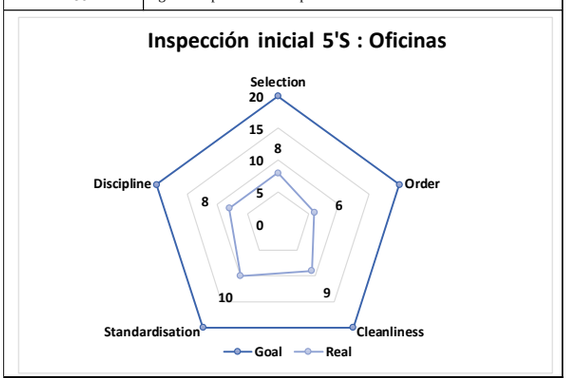
Workshop

In the substation workshop there are no delimitations (see table 6) in the workstations, which can cause health risks to workers, order and selection is an issue to be addressed, reaching an overall score of 41 points, see table 6.

Box 8

Table 6
Initial inspection results: workshops

COMISIÓN FEDERAL DE ELECTRICIDAD			
WESTERN TRANSMISSION AREA			
Department (Criterion): SUBSTATIONS			
Results Initial inspection 5'S methodology			
24 July 2023	Area: Workshop		
Result	**Goal**	**Real**	**Percentage %**
Selection	20	8	**40%**
Order	20	6	**30%**
Cleanliness	20	9	**45%**
Standardisation	20	10	**50%**
Discipline	20	8	**40%**
General	**100**	**41**	**41%**
Colour coding			
81- 100	Outstanding! Strong 5S culture in place		
60 - 80	Strong 5S implementation but room for improvement		
< 60	Significant potential for improvement		



According to Siddiqui et al. (2024), the implementation of energy audits not only optimises efficiency, but also improves the quality of energy supplied, reduces costs and minimises energy waste. The results reflect the lack of a culture of order and cleanliness, it follows that the implementation of the 5S methodology should be taken as a habit to improve the workspace, reduce times in the execution of maintenance activities, increase productivity, quality in the power transmission service, and reduce risks to workers, the most important component for the company.

Conclusions

The analysis indicates that the lack of culture in the application of 5S, together with the accumulation of unnecessary objects and poor signage, are the main causes of these problems. To improve, it is recommended to reinforce the 5S culture, properly organise tools, documents, and improve signage and delimitation of spaces. Implementing these actions will help to create a safer and more productive working environment.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

The initial inspection to analyse the state of order and cleanliness of the substation department has exposed areas for improvement. Using a checklist adapted to the office, warehouse and workshop sub-areas, the levels of compliance with the 5S methodology were evaluated.

To improve conditions, it is recommended to implement corrective actions focused on the organisation of workspaces by implementing a structured filing system for documents and materials, ensuring that all documents are properly classified and stored in specific folders or containers. Create defined workspaces with appropriate furniture to facilitate access and use of tools and documents. Disposal of Unnecessary Items, by making an inventory of all items present in the offices and eliminating those that are unnecessary or not used on a regular basis. Establish procedures for the disposal of obsolete documents and materials, ensuring that safe and efficient disposal practices are followed. Implement a regular cleaning programme that includes daily cleaning of desks, bookcases and other work areas. Assign specific responsibilities to employees or cleaning staff. Provide cleaning materials: Ensure that sufficient cleaning materials, such as disinfectants, wipes and other necessary products, are available and accessible in the offices.

Train staff on the 5S methodology, emphasising the importance of order and cleanliness in the work environment. Promote an organisational culture that values and continuously practices order and cleanliness through workshops, meetings and frequent reminders. Develop and implement clear policies on maintaining order and cleanliness in the workplace, with specific guidelines and expectations. Use visual tools, labels and signage to clearly identify the use of spaces and tools, making them easy to locate and encouraging tidiness. Install dashboards or visualisation systems to track compliance with organisational and housekeeping practices, and to communicate progress and areas for improvement.

The analysis of the work areas by means of the inspection checklist has shown significant deficiencies in the degree of organisation and cleanliness in the sub-areas evaluated: The rigorous implementation of the 5S methodology is essential to improve work spaces, reduce maintenance activity times, increase productivity and minimise occupational risks. Install adequate signage for the identification and location of elements.

In terms of the workshop, it is recommended to clearly delimit work stations and specific areas for different activities. Establish a system of order and labelling for tools and materials.

These solutions will help to improve organisation and cleanliness in the sub-areas, promoting a more efficient and safer working environment.

Annexes

Annex 1

Survey

CFE Comisión Federal de Electricidad	5'S METHODOLOGY
	SURVEY

Below are a series of questions related to the 5's Methodology, please read each question carefully and mark your answer with an "X".

1. ¿Are you familiar with the 5's methodology?
ye ○ No ○
2. Do you consider it important to keep the work areas clean and tidy?
yes ○ No ○
3. Do you have the necessary cleaning equipment to keep the area clean (waste bins, brooms, mops, etc.?
yes ○ No ○
4. Do you have the necessary tools and equipment for the execution of your activities?
yes ○ No ○
5. Do you have a specific place for tools and equipment?
yes ○ No ○
6. How do you consider your productivity?
Excellent ○ Good ○ Regular ○ Insufficient ○
7. Is access within the whole area easy and unobstructed?
Sí ○ No ○
8. ¿Los lineamientos de trabajo establecidos por la organización son cumplidos habitualmente?
Sí ○ No ○
THANK YOU FOR YOUR PARTICIPATION!

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

Annex 2

5S initial inspection checklist: Workshop

5'S AUDIT CHECKLIST					
COMISIÓN FEDERAL DE ELECTRICIDAD					
NORTHERN TRANSMISSION ZONE: Substation Department					
Evaluation date: 24 July 2023			**Objective:** To implement the 5's methodology to improve the efficiency of maintenance and operation processes in the substation department of the Western Transmission Zone of the Federal Electricity Commission.		
Evaluator: 2					
Area: Taller 			***Weightings***		
			4	Excellent	
			3	Good	
			2	Regular	
			1	Insufficient	
			0	Non-compliant	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
1. SEIRI (SELECT)	Differentiating between the necessary and the unnecessary	**1.1**	Work tools and equipment are tidy, in the assigned place, identified and clean.	1	It is observed that the tools do not have a fixed place and that there are unnecessary items in the area.
		1.2	There is clear identification of unsafe conditions in the area, equipment and operations.	2	
		1.3	Walkways and common areas are clear for pedestrians and vehicles to pass through.	2	
		1.4	There are unclassified tools or equipment for the execution of activities.	1	
		1.5	Unnecessary broken / unserviceable items (tools, equipment, PPE) are separated or identified.	2	
			Maximum score:	20	
			Total:	8	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
2. SEITON (ORGANISE)	Ordering of items, establishing a specific location	**2.1**	There are demarcation lines for access, circulation, machinery, storage, etc. (Access routes and demarcation).	2	Some of the workplaces lack area boundaries, and there are no signposts.
		2.2	There are signs and demarcation of areas	0	
		2.3	Equipment and work tools have a fixed place and are always in place.	1	
		2.4	Obsolete items (machinery, tools, equipment) are disorganised	1	
		2.5	The distribution of items (tools, equipment, etc.) is adequate.	2	
			Maximum score:	20	
			Total:	6	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
3.SEISO (CLEANING)	Removing dirt and avoiding soiling	**3.1**	The area is free of dust and dirt.	1	The department has the personnel to clean the area, however, it is not done as often as scheduled.
		3.2	There are dustbins, which are regularly emptied without exceeding their capacity.	1	
		3.3	Visible signage is free of dust and in good condition.	0	
		3.4	Cleaning is carried out as scheduled in the cleaning plan, and is inspected by a person responsible for the area.	3	
		3.5	The necessary cleaning materials are available and accessible.	4	
			Maximum score:	20	
			Total:	9	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
4. SEIKETSU (STANDARDISING)	Getting the first 3's implemented	**4.1**	Cleaning standards are complied with and checked that they are properly applied	1	The area does not comply with the degree of order and cleanliness, although there is a cleaning programme, it is observed that in some areas order is not maintained.
		4.2	Resources for cleaning and work organisation are provided.	3	
		4.3	Personal protective equipment is properly worn by staff and is clean and in good condition.	3	
		4.4	Machinery, equipment and tools are kept clean and maintained in good conditio	1	
		4.5	Visual evidence is used regarding the maintenance of order and cleanliness conditions.	2	
			Maximum score:	20	
			Total:	10	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
5.SHITSUKE (DISCIPLINE)	Make the 5'S activities a habit.	**5.1**	All staff cooperate in the cleaning work.	2	It is observed that the personnel do not adequately apply the 5's, however, they are willing to collaborate to improve the conditions in their work areas.
		5.2	The workstation is handed over and received in optimal conditions: clean and tidy.	0	
		5.3	Inappropriate use of the facilities (disorder) is reported to the person in charge of the area.	2	
		5.4	Signs are respected throughout the facility.	1	
		5.5	Cleanliness, control and tidiness records are kept.	3	
			Maximum score:	20	
			Total:	8	

Annex 3

5S Initial Inspection Checklist: Warehouse

5'S AUDIT CHECKLIST					
COMISIÓN FEDERAL DE ELECTRICIDAD					
NORTHERN TRANSMISSION ZONE: Substation Department					
Evaluation date: 24 July 2023			**Objective:** To implement the 5's methodology to improve the efficiency of maintenance and operation processes in the substation department of the Western Transmission Zone of the Federal Electricity Commission.		
Evaluator: 3					
Area: Substation Department Warehouse 			***Weightings***		
			4	Excellent	
			3	Good	
			2	Regular	
			1	Insufficient	
			0	Non-compliant	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
1. SEIRI (SELECT)	Differentiating between the necessary and the unnecessary	**1.1**	Tools and work equipment are tidy, in the assigned place, identified and clean.	0	Unnecessary objects obstructing the passageway and obsolete documents are observed.
		1.2	There are articles, objects, tools, etc., outside the established area.	2	
		1.3	Walkways and common areas are free for pedestrians to pass through.	0	
		1.4	There are tools or equipment not classified for the execution of activities.	1	
		1.5	Unnecessary broken / unusable items or items from another process (tools, equipment, PPE) are separated or identified.	2	
			Maximum score:	20	
			Total:	5	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
2. SEITON (ORGANISE)	Ordering of items, establishing a specific location	**2.1**	Documents are quickly located	0	The folders of documents, tools and equipment stored in this area have no fixed location, and there are no signposts.
		2.2	Documents (folders), tools and/or equipment have a fixed place and are always in their place	0	
		2.3	Shelves allow for easy access to documents	0	
		2.4	The work area has signs in good condition, the folders (documents) are labelled by sections or areas.	1	
		2.5	The distribution of items (documents, folders, tools, etc.) is adequate.	2	
			Maximum score:	20	
			Total:	3	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
3. SEISO (CLEANING)	Removing dirt and avoiding soiling	**3.1**	The area is free of dust and dirt.	0	The substation department has the necessary cleaning supplies (broom, waste containers, dustpan, etc.), however, there is no cleaning programme in this area.
		3.2	There are dustbins, which are regularly emptied without exceeding their capacity.	0	
		3.3	Visible signage is free of dust and in good condition.	0	
		3.4	Cleaning is carried out as scheduled in the cleaning plan, and is inspected by a person responsible for the area.	0	
		3.5	The necessary cleaning materials are available and accessible.	4	
			Maximum score:	20	
			Total:	4	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
4. SEIKETSU (STANDARDISING)	Getting the first 3's implemented	**4.1**	Standards of cleanliness are adhered to and checked for correct application.	0	The substation storage area does not comply with cleaning registers and does not have signage.
		4.2	Visual evidence is used regarding the maintenance of tidiness and cleanliness.	2	
		4.3	Standardisation tools are in place to maintain order and cleanliness.	2	
		4.4	Resources for cleaning and work organisation are provided.	4	
		4.5	Records of cleanliness, control and tidiness are made.	0	
			Maximum score:	25	
			Total:	8	
Aspects to verify		***No.***	***Description***	***Score***	***Remarks***
5.SHITSUKE (DISCIPLINE)	Make the 5'S activities a habit.	**5.1**	All staff cooperate in the cleaning work.	2	It is observed that the personnel do not adequately apply the 5's, however, they are willing to collaborate to improve the conditions in their work areas.
		5.2	The workstation is handed over and received in optimal conditions: clean and tidy.	0	
		5.3	Inappropriate use of the facilities (disorder) is reported to the person in charge of the area.	1	
		5.4	Signs are respected throughout the facility.	3	
		5.5	Cleanliness, control and tidiness records are kept.	0	
			Maximum score:	25	
			Total:	6	

Declarations

Conflict of interest

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

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

Author contribution

The contribution of each researcher in each of the points developed in this research was defined based on:

Serrano-González, Sergio: Contributed to the project idea, research method and technique, Design of the Gemba walk instrument, 5S initial inspection check list, Ishikawa analysis and initial audit inspection results. I carried out data analysis and results, as well as writing the article.

Maturano-Maturano, Benito Armando: application of the field instrument for initial workshop inspection results. Carried out the processing of background information for the state of the art. Supported the design of the field instrument. Also contributed to the writing of the article.

Castellanos-Lopez, Liliana Yadira: application of the initial workshop inspection results field instrument. She contributed to the research design, the type of research, the approach, the method and the writing of the article.

Alvarado-Reséndiz, José Luis: worked on the application of the initial office inspection results field instrument, data collection and processing of the results. He also worked on the writing and style of the article.

Availability of data and materials

The data and materials used were obtained from the Substation Department of the Western Transmission Zone of the Federal Electricity Commission.

Funding

This work was financed by the Tecnológico Nacional de México Campus Occidente del Estado de Hidalgo, with its own resources.

Acknowledgements

This work was possible thanks to the substation department of the Western Transmission Zone of the Comisión Federal de Electricidad and to Engineer Deisy Paola Jiménez Méndez.

Abbreviations

List abbreviations in alphabetical order.

HMMEL: Tools, Material, Labor, Equipment.
5 's: Seiri, Seiton, Seiso, Seiketsu and Shitsuke

References

Basics

Aldavert, J., Vidal, E., Lorente, J. J. (2018). 5S para la mejora continua: La base del Lean. España: Alda Talent Empresa.

Boero, C. (2020). Mantenimiento industrial: (ed.). Jorge Sarmiento Editor - Universitas.

Castillo-Ruano, G. R., & Banguera-Rojas, D. E. (2018). Evaluación estratégica desde una matriz FODA en la empresa aglomerados. Polo Del Conocimiento, 3(9), 224.

Demirbaş, D., Blackburn, R., & Bennett, D. (2020). Kaizen Philosophy in a Modern Day Business. Istanbul University Press.

Fernández Sánchez, E. Avella Camarero, L. & Fernández Barcala, M. (2020). Administración de la producción: enfoque estratégico: (1 ed.). Difusora Larousse - Ediciones Pirámide.

Muñoz Guevara, J. A., Zapata Urquijo, C. A., & Medina Varela, P. D. (2022). *Lean Manufacturing: Modelos y herramientas*. *Lean Manufacturing: Modelos y herramientas*. Universidad Tecnológica de Pereira - UTP.

Piñero, E. A., Vivas, F. E., & Flores de Valga, L. K. (2018). *Programa 5S´s para el mejoramiento continuo de la calidad y la productividad en los puestos de trabajo*. Ingeniería Industrial. Actualidad y Nuevas Tendencias, VI (20), 99-110.

Socconini Pérez Gómez, L. V. (2019). *Lean Manufacturing: paso a paso:* (ed.). Marge Books.

Suárez Barraza, M. F. (2015). El Kaizen-Coaching: (ed.). Fundación Universidad de las Américas Puebla (UDLAP).

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

Tapia Coronado, J., Escobedo Portillo, T., Barrón López, E., Martínez Moreno, G., & Estebané Ortega, V. (2017). Marco de Referencia de la Aplicación de Manufactura Esbelta en la Industria. Ciencia & Trabajo, 19(60), 171–178.

Vinodh, S. (2022). Lean Manufacturing: Fundamentals, Tools, Approaches, and Industry 4.0 Integration (1st ed.). CRC Press.

References

Corbetta, P. (2023). Metodología y técnicas de investigación social: (1 ed.). McGraw-Hill España.

Rojas, Gregorio N. (2023). Metodología de la investigación para anteproyectos: (1 ed.). Universidad Abierta para Adultos (UAPA).

Discusiones

Arroba Vásquez, N. A. (2022). Aplicación de la metodología 5S para la mejora de la productividad en una empresa productora de papeles absorbentes. Universidad Politécnica Salesiana.

Huamán Meza, E. M., & Rodríguez Bernaola, O. (2021). Implementación de metodología 5S para mejorar la eficiencia del proceso de despacho en una empresa de perforación y voladura, Lima 2020. Universidad Cesar Vallejo.

Lay-De-León, Rosa Nathaly, Acevedo-Urquiaga, Ana Julia, & Acevedo-Suárez, José Antonio. (2022). Guía para la aplicación de una estrategia de mejora continua. Ingeniería Industrial, 43(3), 30-48. Epub 11 de noviembre de 2022.

Luna Altamirano, K. A., Quizhpe Peralta, L. G., & Bravo Chimbo, K. M. B. C. (2020). Plan de mejora enfocado en la seguridad industrial para la empresa Inmeplast basado en las 5S. Ciencia Digital, 4(1), 111-125.

Vargas Crisóstomo, E. L., & Camero Jiménez, J. W. (2021). Aplicación del Lean Manufacturing (5s y Kaizen) para el incremento de la productividad en el área de producción de adhesivos acuosos de una empresa manufacturera. Industrial Data, 24(2), 249-260.

Siddiqui MAH, Chattopadhyaya S, Sharma S, et al. Mejora de la productividad de los paquetes mineros continuos de minas subterráneas con conservación de energía en los sectores industriales. Exploración y Explotación Energética. 2024; 0(0). doi:10.1177/01445987241266084.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Serrano-González, Sergio, Maturano-Maturano, Benito Armando, Castellanos-López, Liliana Yadira and Alvarado-Reséndiz, José Luis. [2024]. 5'S diagnosis in the substation department of the western transmission area. Journal of Architecture and Design. 8[19]-1-11: e20819111.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.11

Journal of Architecture and Design 8[19]1-8: 30819108
Article

Optimization of preventive maintenance in the design of photovoltaic plants

Optimización del mantenimiento preventivo en el diseño de plantas fotovoltaicas

Chavira-Álvarez, Alberto*[a], Pérez-Ortega, Eva Claudia[b] and Esparza-Delgado, María Del Carmen[c]

[a] Universidad Tecnológica de Chihuahua • S-7881-2018 • 0000-0002-2705-6851 • 250601
[b] Universidad Tecnológica de Chihuahua • S-6728-2018 • 0000-0002-4739-9237 • 388994
[c] Universidad Tecnológica de Chihuahua • S-7823- 2018 • 0000 0001 8276 6031 • 520791

CONAHCYT classification:

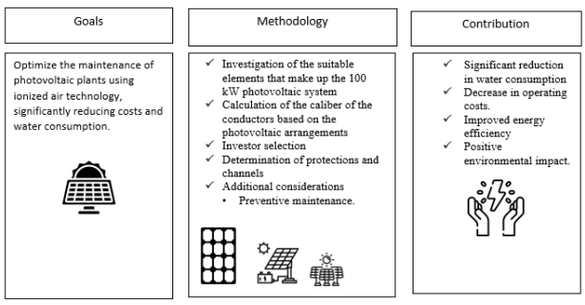
Area: Engineering
Field: Technological sciences
Discipline: Energy technology
Subdiscipline: Energy generation

https://doi.org/10.35429/JAD.2024.8.19.3.8
History of the article:
Received: January 13, 2024
Accepted: December 31, 2024

* ✉ [evaperez@utch.edu.mx]

Abstract

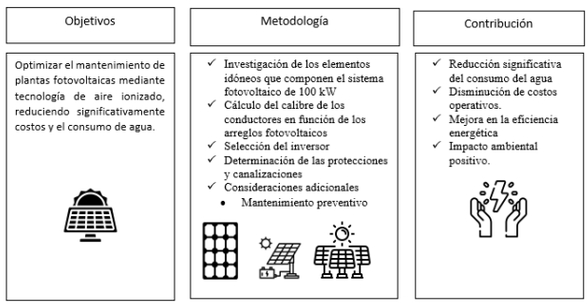
Two of the biggest problems worldwide are electrical energy and water, in this context the use of photovoltaic systems for the generation of electrical energy is increasingly profitable due to the constant reduction of prices in terms of the dollar watt and that supports the solution to the problem of energy supply at increasingly affordable prices. In this same scenario we have a reduction in CO2 emissions, contributing to the reduction of greenhouse gases, supporting the Kyoto protocol and the Paris agreement. On the other hand, the incorporation of ionized air for cleaning the photovoltaic modules allows the use of natural and demineralized water to be reduced to levels of around 98%, which allows us to be on par in saving solutions for this vital liquid.



Energy, Solar, Panel

Resumen

Dos de los mayores problemas a nivel mundial es la energía eléctrica y el agua, bajo este contexto la utilización de los sistemas fotovoltaicos para la generación de energía eléctrica es cada vez más rentable por la constante reducción de precios en cuanto a la relación dólar watt y que apoya en la solución a la problemática de abastecimiento energético a precios cada vez más asequibles. En este mismo escenario tenemos una reducción de las emisiones de CO2, contribuyendo a la reducción de gases de efecto invernadero, apoyando el protocolo de Kioto y el acuerdo de París. Por otro lado, la incorporación de aire ionizado para la limpieza de los módulos fotovoltaicos permite reducir a niveles de alrededor de 98% el uso del agua natural y desmineralizada, lo que permite estar a la par en las soluciones de ahorro de este vital líquido.



Energía, Solar, Panel

Citation: Chavira-Álvarez, Alberto, Pérez-Ortega, Eva Claudia and Esparza-Delgado, María Del Carmen. [2024]. Optimization of preventive maintenance in the design of photovoltaic plants. Journal of Architecture and Design. 8[19]-1-8: e30819108.

Introduction

In the context of an increasingly environmentally conscious world and businesses in constant search for cost reduction when operating, sustainable energy sources have gained great importance. For this reason, the design and subsequent optimisation of the 100 kW photovoltaic plant is described throughout this article. The main objective of the installation is to generate clean energy and reduce the carbon footprint. The following details the approach taken in the electrical design of the installation, from the choice of components to the calculations of conductors and protections and how automation is implemented to improve efficiency and reduce risks. The use of renewable energy in a plant environment can give the company the competitive advantage of reducing reliance on energy from traditional sources and the risks associated with the costs involved. The plant in question is just one example of how sustainable practices can go hand in hand with efficiency and responsibility.

Theoretical framework

Fundamentals of Electrical Design in Photovoltaic Plants

The electrical design of a PV plant is fundamental to ensure that the system operates in an efficient and stable manner. This process involves the choice and layout of solar panels, inverters, wiring and protection systems, each with a crucial role in the overall performance of the system.

Solar panels are a fundamental part of the PV system. These panels convert sunlight into direct current (DC). The efficiency of the panels depends on the quality of their materials and the design of the solar cells. In addition, the way the panels are oriented and tilted affects how much energy they can capture. For example, an incorrect tilt angle can significantly reduce energy production (Chen & Huang, 2020).

Inverters are another key component. They convert the direct current generated by the panels into alternating current (AC), which is used in the electricity grid. There are several types of inverters, each with its advantages and disadvantages.

Central inverters, for example, are ideal for large installations because they handle large volumes of power economically (Baker & Perez, 2022). String inverters, which connect several panels in series, offer more flexibility and may be better for systems with varied configurations. Finally, microinverters connect to each panel individually and can be useful in installations where there are shading issues (Castro & Figueroa, 2023).

Optimising photovoltaic performance

Optimising the performance of photovoltaic systems is crucial to get the most out of solar energy. To achieve this, several factors can be adjusted, such as the tilt angle of the panels, using sun-following systems and reducing shading (Bertoni & Ferrara, 2021). The angle at which the panels are placed should be adapted to the latitude and seasons of the year to capture as much solar radiation as possible.

Sun-tracking systems, which adjust the orientation of the panels throughout the day, can increase energy production compared to fixed systems. Although these systems can be more expensive and require more maintenance (González & Martínez, 2023), they can justify their additional cost with the increase in energy production. In addition, monitoring technologies allow system performance to be monitored in real time, making it easier to identify and solve problems that may affect efficiency (Kumar & Singh, 2023).

Inverter technologies and their impact

Choosing the right inverter technology can make a big difference in the efficiency of a PV system. Central inverters, which group the output of several panels at a single point, are generally the most economical option for large installations (Hassan & Ahmed, 2022).

On the other hand, string inverters allow more flexibility and can be more efficient in systems with various configurations (Kim & Lee, 2021) [VIII]. Microinverters, which optimise each panel individually, are ideal for installations with shading or uneven tilt problems (Castro & Figueroa, 2023).

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Chavira-Álvarez, Alberto, Pérez-Ortega, Eva Claudia and Esparza-Delgado, María Del Carmen. [2024]. Optimization of preventive maintenance in the design of photovoltaic plants. Journal of Architecture and Design. 8[19]-1-8: e30819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

Wiring and protection design

The wiring in a PV plant must be well designed to avoid energy losses and ensure safety. The cables must be robust enough to handle the current generated by the panels without overheating (Davis & Jones, 2022). In addition, it is important to consider the distance between the panels and the inverter and how environmental conditions can affect the cables.

Protection of the system is essential to avoid damage. Protective devices, such as circuit breakers and fuses, should be used to prevent overloads and short circuits. These devices must be suitable for the specific system to ensure that everything works safely and efficiently (Fernandez & Lopez, 2021).

Performance Evaluation and Maintenance

In order to keep a PV plant in optimal condition, continuous performance evaluation and preventive maintenance is crucial. Modern systems make it possible to monitor energy production in real time and detect potential problems before they become serious problems (López & Moreno, 2021).

Preventive maintenance, which includes cleaning panels and checking connections, can extend the life of the system and ensure that it continues to operate at its maximum capacity (Smith & Wang, 2022).

Methodology

Investigation of the Suitable Elements of the 100 kW Photovoltaic System

The first step in developing an efficient PV system is to carefully select the components that optimise the energy production, durability and safety of the system. The main elements of a 100 kW PV system are solar panels, inverters, conductors, mounting systems and protection devices.

Solar Panels

The solar panels are the heart of the system, as they convert solar radiation into electricity. For a 100 kW system, it is essential to select highly efficient and durable modules.

Currently, panels typically have an output of between 320 and 450 W per module. To reach 100 kW, between 222 and 312 modules are required, depending on their capacity (100 kW / 450 W ≈ 222 modules).

In addition to the power, it is important to consider the efficiency of the modules. Panels with efficiencies above 18% allow for a reduction in the number of modules and optimisation of the available installation space. Monocrystalline modules are commonly preferred for their higher efficiency, especially in low irradiation conditions.

Inverters

Inverters are essential for converting the direct current (DC) generated by the panels into alternating current (AC), which is used in power grids. The selection of a suitable inverter is key to maximising efficiency and ensuring the correct operation of the system under various conditions.

Mounting systems

Support structures should be selected considering whether the installation will be roof or ground mounted, the climatic conditions of the site and the optimal orientation to maximise solar radiation collection. Structures made of corrosion resistant materials, such as galvanised steel or aluminium, are recommended to ensure the longevity of the system.

Electrical protections

The system must have adequate safeguards to prevent damage to components and ensure safety. This includes overvoltage, short-circuit and overload protection, as well as a grounding system that protects against electric shock and complies with safety regulations.

Trunking and conductors

The design must provide for adequate conduits and conductors for power transmission. Selecting the correct conductors is essential to minimise voltage drop losses and ensure the safety of the system. Conduits must protect the conductors from mechanical damage and adverse environmental conditions.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Chavira-Álvarez, Alberto, Pérez-Ortega, Eva Claudia and Esparza-Delgado, María Del Carmen. [2024]. Optimization of preventive maintenance in the design of photovoltaic plants. Journal of Architecture and Design. 8[19]-1-8: e30819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

Calculating conductor sizing for photovoltaic arrangements

The calculation of the conductor size is crucial to ensure the efficiency and safety of the system. The size of the conductors depends on the current, the distance, the allowable voltage drop and the ambient temperature.

Current determination

To calculate the conductor size, the maximum current must first be determined. This current is calculated by dividing the system power by the operating voltage. For a 100 kW system operating at 1000 V, the current would be: I=(100,000 W/1000 V)=100 A.

Size selection according to voltage drop

The conductor size is selected by considering the voltage drop, which normally should not exceed 3% of the nominal voltage. The formula for voltage drop is: Vd=(2·I·L·R)/A where Vd is the voltage drop, I is the current, L is the conductor length, R is the resistivity of the material, and A is the conductor cross-section. The rating is adjusted to keep the voltage drop within the allowable limits.

Inverter Selection

Correct inverter selection is vital to ensure efficient operation. The inverter must handle the power generated by the panels and convert it into alternating current (AC).

Inverter Types

There are three main types of inverters:

1. Central inverters: Suitable for large installations.

2. String inverters: Connected to groups of modules, they offer flexibility.

3. Microinverters: These are placed in each panel and optimise individual production, more common in small installations.

Selection Criteria

The inverter must be capable of handling at least 100 kW, preferably with a 10% margin to cover production peaks. Its input voltage should match that of the PV arrays. In addition, it is advisable to select inverters with an efficiency of more than 97% to minimise losses.

Determination of the Protections and Trunking

It is necessary to select adequate protection devices and design conduits that comply with electrical safety regulations.

Electrical Protections

Systems require overvoltage, overload and short-circuit protection, including circuit breakers, fuses and transient surge protectors.

Trunking

Conduits must protect conductors from damage and comply with local regulations, such as the Mexican Official Standard NOM-001-SEDE-2012. In outdoor installations, the use of metallic or PVC conduits is recommended, depending on environmental conditions.

Additional Considerations

System Monitoring and Control

The integration of automated monitoring systems is recommended to measure real-time energy production, operating conditions, and detect faults.

Some software options used for the design of 100 kW PV plants, highlighting their main features, benefits and applications:

Comparative Analysis

PVSyst is one of the most widely used software for PV system design due to its accurate and detailed simulation capabilities.

Benefits:

- Provides comprehensive analyses of annual energy production.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Chavira-Álvarez, Alberto, Pérez-Ortega, Eva Claudia and Esparza-Delgado, María Del Carmen. [2024]. Optimization of preventive maintenance in the design of photovoltaic plants. Journal of Architecture and Design. 8[19]-1-8: e30819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

- Simulates losses due to factors such as shading, temperature and internal resistances.

- Useful for sizing both small and large systems.

Limitations: Interface can be complex for novice users.

Ideal Use: Small and large-scale projects that require accurate simulation of long-term performance.

Helioscope this software excels in ease of use and speed of design, allowing you to simulate environmental conditions in real time.

Benefits:

- Fast simulations with real-time modelling.

- Calculate shading and optimise panel placement.

- Includes financial analysis.

Limitations: Lacks some of the advanced detail in electrical system modelling that PVSyst offers.

Ideal Use: Medium to large projects requiring fast simulations and detailed design and shading analysis.

SolarEdge Designer this software is specific to systems using SolarEdge inverters and optimisers, making it ideal when using their equipment.

Benefits:

- Optimises system efficiency for installations with SolarEdge equipment.

- Detailed wiring and shading loss simulations.

Limitations: Limited to systems with SolarEdge technology, which restricts its use to these devices.

Ideal Use: Projects using the SolarEdge brand, especially in commercial and industrial installations.

AutoCAD although not a specific software for PV design, is essential in the technical and physical planning of the plant.

Benefits:

- High accuracy in planning physical and electrical layouts.

- Integration with other design and simulation systems.

Limitations: Does not offer energy simulations or loss analysis.

Ideal Use: Projects where detailed physical design is essential, complementing other simulation software.

SAM (System Advisor Model) is a software developed by NREL that combines energy analysis with financial analysis, based on meteorological data.

Benefits:

- Performs energy production simulations based on historical weather data.

- Integrates financial analysis to assess the economic viability of the project.

Limitations: May not be as detailed in simulations of shading or voltage drops as other programs.

Ideal Use: Projects that require financial feasibility assessment along with energy analysis.

Preventive maintenance

The system should include a preventive maintenance plan to prolong the life of the components and ensure their continued operation. This includes cleaning of panels, inspection of connections and calibration of monitoring systems.

Maintenance of solar panels is essential to ensure their optimal performance and to prolong their lifetime. There are different methods to clean them, the most common of which include the use of water and ionised air.

1. Water cleaning

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Chavira-Álvarez, Alberto, Pérez-Ortega, Eva Claudia and Esparza-Delgado, María Del Carmen. [2024]. Optimization of preventive maintenance in the design of photovoltaic plants. Journal of Architecture and Design. 8[19]-1-8: e30819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

Water cleaning is one of the most traditional and effective techniques, especially in areas with significant accumulation of dust, dirt, or organic debris. Some considerations are:

Demineralised or distilled water: It is advisable to use mineral-free water to avoid staining by mineral residues that can reduce the efficiency of the panels.

Automated cleaning systems: These systems use pressurised water jets to clean the panels, minimising the risk of damage and reducing manual effort.

Frequency: Water cleaning is usually carried out once or twice a year, depending on the environment. In arid or highly polluted areas, more frequent cleaning may be required.

Caution with chemicals: The use of aggressive chemicals that may damage the surface of the panels or affect the anti-reflective coating should be avoided.

2. Cleaning with Ionised Air

Ionised air is an advanced technology that is being used for cleaning solar panels, especially in areas where access to water is limited or expensive. This method involves the use of ion-charged air, which effectively removes dust and other contaminants without direct physical contact. Advantages include:

No water use: Ideal for areas where water is a scarce resource.

Efficiency without residue: Ionised air removes particles without leaving residue, preventing staining or corrosion.

Less wear and tear: By not using water or brushes, there is less risk of damage to panels or scratches to their surface.

Automation: This method can be easily automated, with robots or devices installed that clean the panels on a continuous or scheduled basis.

Comparison of methods

Traditional Method (Demineralised Water and Vinegar).

The traditional method of cleaning solar panels is based on the use of demineralised water and, in some cases, a mixture of white vinegar with calcium bicarbonate to remove mineral deposits. The main costs associated with this process are:

Demineralised water: 20 litres cost between 240 and 280 pesos, which translates into a considerable expense if frequent cleaning is required. When water pipes are used (19,000 litres at 6,000 pesos), the monthly cost amounts to 24,000 pesos, which implies an annual cost of 78,000 pesos for water alone.

Labour: To carry out maintenance, specialised personnel are required, the annual cost of which, considering two workers with a salary of 2,000 pesos per week plus benefits, amounts to 208,000 pesos.

Vinegar and bicarbonate: This compound is used twice a year to remove carbonate incrustations on the panels. This involves an additional 134,500 pesos per year in white vinegar (1,000 litres).

This method is not only more costly in terms of inputs and labour, but also has a significant environmental impact due to the high water usage.

Innovative Method (Ionised Air)

On the other hand, the use of ionised air represents a modern and more efficient alternative, with the following benefits:

Ionisation kit: This kit, which includes a gun and compressor, has an initial cost of just 827 pesos. In addition, it does not require the constant use of water, except in specific cases such as cleaning bird droppings.

Water savings: With ionised air, water use can be reduced by up to 98%, which not only reduces operating costs, but also the environmental impact. Annual water savings are estimated at 78,000 pesos.

Reduced chemical usage: The need to remove carbonate scale is no longer a constant problem, saving an additional 134,500 pesos per year on products such as vinegar and bicarbonate.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Chavira-Álvarez, Alberto, Pérez-Ortega, Eva Claudia and Esparza-Delgado, María Del Carmen. [2024]. Optimization of preventive maintenance in the design of photovoltaic plants. Journal of Architecture and Design. 8[19]-1-8: e30819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

Results

When comparing the two methods, the use of ionised air shows clear advantages. Not only does this system significantly reduce operating costs (more than 200,000 pesos per year in water and product savings), but it also improves the efficiency of the panels by keeping them clean continuously and without complicated procedures.

In terms of environmental impact, the reduction of water use (up to 98%) is a substantial benefit, especially in areas where this resource is scarce. In addition, the reduced use of chemicals reduces the ecological footprint of the maintenance process.

From a labour and safety perspective, the ionised air method is also favourable as it requires less direct human intervention, which increases worker safety by avoiding exposure to chemicals and water-intensive tasks. In addition, this system allows for greater optimisation of maintenance time, being faster and less intrusive than the traditional method.

Conclusions

By using the 499 KW photovoltaic installation of the Technological University of Chihuahua as a test laboratory, it could be seen that the use of ionised air for cleaning purposes was more efficient in that the blowing is carried out every four weeks and there is much less dispersion of solids or particles adhered to the surface of the module than using water for cleaning.

We were able to observe that the ionised air does not leave residues as the water we use does, as it is well water extracted at a depth of 120 metres, dragging with it multiple particles including calcium carbonate. As it is well water, the hardness of the water is high, due to the large amount of magnesium and calcium present in it, which results in these residues becoming embedded in the surface of the photovoltaic module, causing an attenuation of the reception of solar energy and a drop in the module's efficiency. On the other hand, if demineralised water is used, the cost of preventive maintenance increases significantly.

As the State of Chihuahua is a desert region, very arid, with constant droughts that last between 8 and 11 years and therefore the large amount of dust that exists in the environment is constantly impregnating the surface of the photovoltaic modules, preventive maintenance is more recurrent, about every 4 weeks and in the months of February to April, this is every 3 weeks, due to the windy season. The use of ionised air reduced maintenance costs, eliminating up to 98% of well water, not to mention demineralised water, which is completely eliminated, as ionised air does not leave residues that attenuate the reception of sunlight. Derived from the above statements, already purchased at the photovoltaic plant of the Technological University of Chihuahua, it is concluded that, in terms of preventive maintenance cost savings, it is better to use ionised air.

References

Background

Chen, J., & Huang, X. (2020). Optimization strategies for photovoltaic power systems. Renewable Energy, 152, 598-609.

Baker, K., & Perez, R. (2022). Electrical design considerations for photovoltaic systems. **IEEE Transactions on Sustainable Energy, 13**(2), 234-245.

Basics

Castro, R., & Figueroa, J. (2023). Impact of inverter technologies on photovoltaic system performance. **Energy Conversion and Management, 253**, 115-126.

Kumar, P., & Singh, R. (2023). The impact of electrical system design on photovoltaic efficiency. **Renewable and Sustainable Energy Reviews, 169**, 112842.

Fernandez, A., & Lopez, M. (2021). Electrical design considerations in photovoltaic installations. **International Journal of Energy Research, 45**(7), 1060-1075.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Chavira-Álvarez, Alberto, Pérez-Ortega, Eva Claudia and Esparza-Delgado, María Del Carmen. [2024]. Optimization of preventive maintenance in the design of photovoltaic plants. Journal of Architecture and Design. 8[19]-1-8: e30819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

Support

Bertoni, M., & Ferrara, M. (2021). An analysis of photovoltaic system optimization techniques. Journal of Renewable and Sustainable Energy, 13(4), 456-470.

Gonzalez, P., & Martinez, A. (2023). Enhancing efficiency in photovoltaic systems: Techniques and methodologies. Journal of Solar Energy Engineering, 145(2), 021012.

Differences

Hassan, S., & Ahmed, I. (2022). The role of electrical design in maximizing photovoltaic system performance. **Journal of Electrical Engineering & Technology, 17** (1), 195-205.

Lopez, C., & Moreno, A. (2021). Electrical design optimization in solar photovoltaic plants. Renewable Energy Reviews, 12 (3), 214-229.

Discussion

Kim, J., & Lee, S. (2021). Innovations in photovoltaic system design and their impacts. Energy Reports, 7, 347-360.

Davis, M., & Jones, A. (2022). Design and analysis of solar photovoltaic systems: A review. Energy Reports, 8, 712-726.

Smith, T., & Wang, L. (2022). Evaluating electrical performance in photovoltaic systems. Journal of Solar Energy Research, 18(2), 198-210.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Chavira-Álvarez, Alberto, Pérez-Ortega, Eva Claudia and Esparza-Delgado, María Del Carmen. [2024]. Optimization of preventive maintenance in the design of photovoltaic plants. Journal of Architecture and Design. 8[19]-1-8: e30819108.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.8

Journal of Architecture and Design 8[19]1-13: 40819113
Article

Augmented reality in the educational context for the digitalization of products and mathematical applications

Realidad aumentada en el contexto educativo para la digitalización de productos y aplicaciones matemáticas

Del Carmen-Morales, Yucels Anaí*[a], Del Carmen-Morales, Heidi[b], Felipe-Redondo, Ana María[c] and Juárez-Castillo, Efrén[d]

[a] Universidad Tecnológica de la Huasteca Hidalguense • I-6613-2018 • 0000-0003-2738-4780 • 905179
[b] Universidad Tecnológica de la Huasteca Hidalguense • O6682-2018 • 0000-0002-9686-1838 • 926525
[c] Universidad Tecnológica de la Huasteca Hidalguense • O7111-2018 • 0000-0002-8579-6532 • 835952
[d] Universidad Tecnológica de la Huasteca Hidalguense • AAS56982020 • 0000-0002-2136-2516 • 344990

CONAHCYT classification:

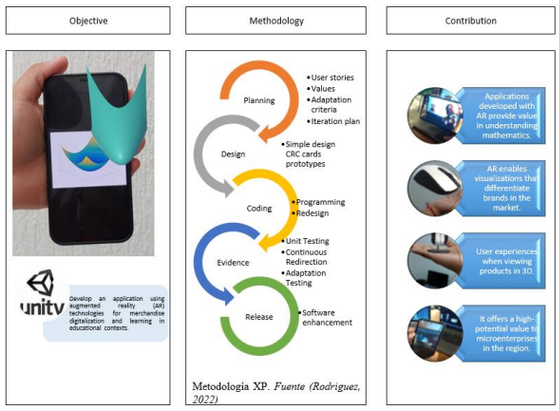
Area: Engineering
Field: Engineering
Discipline: Systems engineer
Subdiscipline: Computer Sciences

https://doi.org/10.35429/JAD.2024.8.19.1.13
History of the article:
Received: January 19, 2024
Accepted: December 31, 2024

* ✉ [yucels.delcarmen@uthh.edu.mx]

Abstract

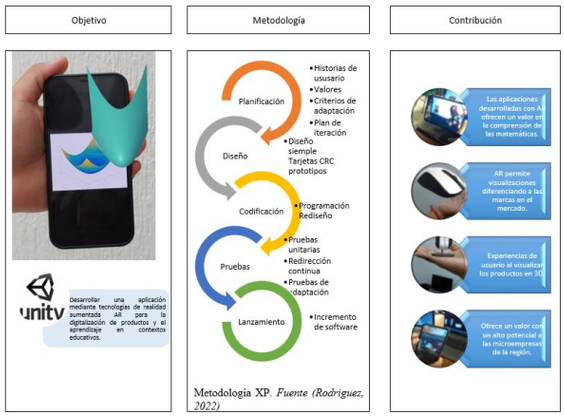
The objective of this project was to develop an application using AR augmented reality technologies for the digitalization of products and learning in educational contexts. The extreme programming (XP) methodology was used for its development which comprises the stages: planning, design, coding, testing, launch. As a result integrating Vuforia into Unity enabled the creation of augmented reality (AR) applications for mobile devices in this project was used the operating system of Android, Tests were carried out to determine how Vuforia works in Unity using Image Targets and 3D Models, an installation manual was developed for beginners to integrate their knowledge, practical problem solving, Interactivity and meaningful learning.



vuforia, Augmented realit

Resumen

El objetivo de este proyecto fue desarrollar una aplicación mediante tecnologías de realidad aumentada AR para la digitalización de productos y el aprendizaje en contextos educativos. Se utilizó la metodología de programación extrema (XP) para su desarrollo que comprende las etapas de: planificación, diseño, codificación, pruebas, lanzamiento. Como resultado integrar Vuforia en Unity permitió la creación de aplicaciones de realidad aumentada (AR) para dispositivos móviles en este proyecto se utilizó el sistema operativo de Android. Se realizaron pruebas para poder determinar cómo es el funcionamiento de Vuforia en Unity mediante Image Targets y Modelos 3D, también se elaboró un manual de instalación enfocado a principiantes con la finalidad de que puedan integrar sus conocimientos, resolución de problemas prácticos, interactividad y aprendizaje significativo.



Unity, vuforia, Realidad aumentada

Citation: Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.

Introduction

(De la Horra, 2017) indicates that the pedagogical use of augmented reality (AR) is a tool to obtain two fundamental pillars on which the day-to-day life of the classroom is based: motivation and learning. It is necessary that these new innovative tools meet the fundamental requirements for their use, in this case, in the field of education and training. Some of them are: ease of creation of material for the teacher, ease of use for the student, attractive and user-friendly interface and interdisciplinarity.

Augmented reality is a tool with very special characteristics that give it great possibilities for inclusion in the educational and training sphere. Its versatility, transversality and ease of use make the user feel comfortable during the learning process. Thanks to the development of mobile devices, augmented reality is closer than ever to the user.

The project was developed at the Universidad Tecnológica de la Huasteca Hidalguense because currently, students of the educational programme of Engineering in Software Development and Management, take the subject of mathematics I, where they make use of 3D graphics and multivariable calculation problems, in addition to this they carry out a transversal project for micro-businesses in the region but lack the knowledge to develop a tool that allows them to visualise in augmented reality, which hinders their understanding and application in the digitisation of products and mathematical models.

Given the aforementioned problems, one area of opportunity was the integration of augmented reality in a mobile application for the educational environment so that students can visualise and acquire applied learning.

A tool was developed as an innovative solution, to enhance the applied learning experience, to generate a significant impact by solving specific problems, Unity and Vuforia will be used for the generation of augmented reality (AR) models.

In the commercial environment, the presentation of products online using AR technology brings value to their products or services by generating a positive impact on sales, brand image and competitive position. The objective of this project was to develop an application using AR augmented reality technologies for product digitalisation and learning in educational contexts.

Theoretical foundations

Augmented reality

Augmented Reality, hereafter AR, is a technology that superimposes images, 3D models or other computer-generated information on a real image obtained through a screen. It is a new window through which the world can be seen in an enriched form. Also, 'Augmented reality is about combining the real world with the virtual world through a computer process, enriching the visual experience and improving the quality of communication'.

Levels of augmented reality

Augmented Reality can be classified into levels according to the way it works, parameters, tracking systems and techniques used.

Level 0: hyperlinks in the physical world. The triggers at this level are QR codes that link to websites. A QR code (Quick Response code) is a module for storing information in a dot matrix or two-dimensional barcode. It was created in 1994 by the Japanese company Denso Wave, a subsidiary of Toyota.

Level 1: augmented reality based on reference markers. These are objects used for the observation of imaging systems, which appear in the image to be used as a reference or measurement point. At this level the triggers are markers, figures that when scanned usually result in a 3D model that is superimposed on the real image. The markers need a unique pattern, which will allow the camera to recognise and determine the object(s) to be displayed.

The markers usually consist of a black square with a certain pattern inside it, which allows them to be differentiated from each other.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

Level 2: augmented reality without markers. Activators are images, objects or GPS locations. In recent years (since 2009), applications for mobile devices called augmented reality navigators have been developed; these applications use smartphone hardware (GPS, compass and accelerometer) to locate and overlay a layer of information about points of interest in our environment (Figure 4). When the user moves the smartphone around capturing the image of their surroundings, the browser, based on a map of data, displays nearby points of interest (POIs).

Level 3: augmented vision. The purpose of augmented reality incorporated in glasses is to display information available to users without using their hands, also allowing access to the internet through voice commands.

Augmented reality in education

Education is also starting to take advantage of mobile applications (apps) and Augmented Reality (AR). For both teachers and students, AR educational apps can provide highly entertaining and useful learning tools, exploiting the visual component as their main attraction, using animations and videos. For example, AR is of great importance in subjects that require a more practical dimension, such as physics and chemistry. In this way, it is of vital importance that the educational field is driven by technology and one way of impact is to develop an application in an AR environment where teaching for children is more important and attractive than the current violent games, as these create disruption in teaching and do not support any progress for their education and much less for the future of our country.

The educational and technological reality in the classrooms of the different academic levels in our educational system today, comes our educational system today, comes hand in hand with the incorporation of new tools that bring students and teachers tools that bring students closer, in a simple, fun and formative way, to the curricular contents, to curricular content in a simple, fun and educational way. One of the technologies that is currently gaining momentum and importance is is Augmented Reality, which has been gaining ground, especially in higher education in higher education.

AR technology as a teaching resource

AR is a technology that enables a learning-¬-teaching methodology based on these principles: Augmented reality visibly introduces the knowledge that the student has to learn within his or her real environment. The abstraction of the new knowledge is visible and is in the learner's real physical environment. The experience is underpinning the learning.

This new ‘reality of the learning process’ entails a new learning experience as opposed to other resources. In addition, the novelty factor, the emerging technology factor and the ‘reality’ factor can lead to an increase in the students' level of understanding, in the effectiveness of the learning process and in the motivation to learn.

Vocational training and skills development

Vocational training is one of the major areas of application of Augmented Reality, being able to recreate real work situations and improve understanding in practical training activities by superimposing relevant information to allow better monitoring of processes.

In this context, Augmented Reality can offer, for example, the possibility of interacting with industrial machinery on which a layer of data is displayed to provide additional information on its use, thus improving the training of assembly and maintenance technicians and preventing possible errors in its handling.

In the field of vocational training, Augmented Reality can become a tool that facilitates the acquisition of practical learning in virtual training or e-learning processes. The development of Augmented Reality tele-training platforms would allow the possibility of reproducing tailor-made work contexts, with the aim of providing more practical training and solving the shortcomings of online training in this sense, providing access to content that can only be offered by face-to-face training.

Fields of augmented reality

AR has been used to create unique experiences, engage audiences and improve the way media is used.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

The entertainment sector, particularly video games incorporating AR, is expected to remain the largest segment in the B2C (business to consumer) AR software market, reaching EUR 1.65 billion by 2027. Thus, in terms of the use of AR in the entertainment sector, it is worth mentioning:

- Games: AR has revolutionised gaming by providing immersive and interactive experiences that combine the virtual and physical worlds. One of the most representative examples is Harry Potter: Wizards Unite, based on the Harry Potter franchise, developed in 2019 by the creators of Pokémon GO.

- Live events: AR is being used in live events such as concerts, sporting events and theatrical performances to provide unique and immersive experiences for the audience. An example of such experiences is the FIFA+ Stadium Experience associated with live matches at the Qatar 2022 World Cup, which allowed viewers to visualise additional information about players and game metrics.

- Film and TV: AR is being used to create interactive content that allows audiences to interact with their favourite programmes and characters in new ways. For example, the 2021 Super Bowl TV broadcast used a virtual AR stadium to enhance the viewing experience, allowing the game to be viewed from different angles and providing additional statistics and information.

It is possible to learn by playing and through games and with Augmented Reality technology, achieve a better approach to our students, increase motivation, greater interaction and immersion and more meaningful learning.

Augmented Reality as a sales strategy

Business models in companies are undergoing far-reaching changes to the extent that e-commerce is establishing itself as a benchmark, through its business-to-consumer format, it allows entering the digital market in collaboration with vision technologies such as augmented reality.

One factor to be included are the technological tools, in the sales process, adding a differentiator from the competition adds value to the good or service offered to the customer. AR offers the possibility of enriching the multimedia content of the article, interaction with three-dimensional objects and the exploration of a virtual world with smart devices.

Consumer experiences and behaviour

AR has the potential to significantly impact the so-called consumer journey by enhancing user experiences, delivering personalised content and facilitating informed purchasing decisions. Thus, AR enables the creation of immersive and interactive experiences that can enrich the consumer journey at various touch points, from product discovery to post-purchase engagement.

During the pre-purchase stage, consumers become aware of their needs and begin to seek information about possible solutions. As is well known, this stage includes processes such as problem recognition, information search and evaluation of alternatives. In this regard, research on AR often points out how the inclusion of virtual information within the context of consumers can reduce purchase uncertainty. They have shown that embedding branded content in physical contexts relieves consumers of the mental burden of imagining a product. Therefore, virtual content can influence perceptions of ease of use and information consumption.

Compared to traditional media, such as 2D images and text, 3D virtual technologies feature 360-degree rotation, which offers enhanced product/environmental realism, rich imagery and rapid information transfer. Users easily manipulate visual spaces through advanced virtuality features such as zoom and rotation.

From a retail management point of view, AR reduces the extent of stock, as virtual content can replace the need for an assortment that allows for consumer trial.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

In terms of the purchase stage, i.e. the specific moment when the consumer makes the decision to buy a good or service and executes that action, AR ads improve consumers' physiological responses, increase their engagement and facilitate the exchange of social experiences between them (Morejón, 2023).

Shopping experiences and their relationship to augmented reality

In the pandemic, many brands were forced to close their physical spaces and conduct their commercial activity online with the help of tools such as augmented reality.

According to the Mexican Association of Online Sales COVID-19 brought with it an increase in purchases and sales in virtual environments by increasing by 81% in 2020 compared to 2019. Likewise, COVID-19 brought health restrictions, which were implemented by the federal government. This situation reshaped consumer habits, as the implemented social distancing influenced consumers to prioritise online shopping.

A report by the consultancy predicts that the number of augmented reality applications for retail will increase from 12 million in 2019 to almost 3 billion in 2024.

Those actions that use AR as a tool manage to meet 4 basic requirements of advertising effectiveness:

- Interact with the consumer.
- Create personalised content.
- Measure results in real time.
- Impress the consumer and make them remember the advertising.

Enterprise use has dominated the augmented reality conversation for the past few years, the tide is turning. All of the technology companies that can change markets on a global scale are already directly involved in AR, and many are planning more dedicated AR hardware efforts in the next two to three years.

During the pandemic, digital commerce saw tremendous growth. According to AMVO, in the Retail sector alone, e-commerce grew 81% in 2020 compared to 2019, and accounted for 9% of the total retail channel in Mexico.

As shops closed dressing rooms and eliminated product trials, brands implemented technologies such as Augmented Reality (AR) to allow customers to try their products virtually, while helping them make a purchase decision.

Today, consumers are ready for a new way of shopping. In fact, more than 71% of customers are confident that they would shop more frequently if they could use AR tools.

One study found the following:

- 1 in 3 shoppers already use AR
- 71% of consumers would shop more often in a shop if the store offered AR.
- 47% would prefer to use AR both in-store and online
- 40% would be willing to pay more to brands that already offer AR

3D modelling tools

Using object modelling tools and AR applications, teachers and students can create and visualise 3D models and manipulate them: zoom in, zoom out, rotate them, place them in specific locations or explore their physical properties.

Vuforia in Unity

Vuforia Studio is an easy-to-use, web-native tool for creating task- and domain-specific experiences. These experiences provide a holistic view of digital and physical product data, dashboards and prompts in 2D, 3D and augmented reality. Once an experience has been created with Vuforia Studio and published to Experience Service, it can be viewed with the Vuforia View application on a supported device. The Unity editor is a popular and useful authoring platform for creating cutting-edge augmented reality experiences for wearable devices and digital glasses.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

Wikitude

Wikitude is an augmented reality technology tool, created from 2008 and one of the pioneers in exposing a different location-based perspective for augmented reality. In 2012, the company redesigned its offering by launching a development system that employs image recognition, image tracking and geolocation technologies called Wikitude SDK; years later, Wikitude introduced its SLAM technology, which comprises localisation, mapping and also instant tracking of objects without markers.

It allows you to create AR experiences with image recognition, geolocation and markers. Compatible with iOS, Android, Windows and Smart Glasses.

AR.js

Lightweight library for Augmented Reality on the Web, which comes with features such as image tracking, location-based AR and marker tracking. The interesting thing about this library is that it works very well with AFrame which is a library for creating virtual reality experiences on the web.

Methodology

Extreme programming (XP) is a software engineering development methodology formulated by Kent Beck, author of the first book on the subject, Extreme Programming Explained: It is the most prominent of the agile software development processes. Like these, extreme programming differs from traditional methodologies mainly in that it places more emphasis on adaptability than predictability.

Extreme programming can be considered as the adoption of the best development methodologies according to what is intended to be carried out with the project, and applying it dynamically during the software life cycle (Rodriguez, 2022)

Box 1

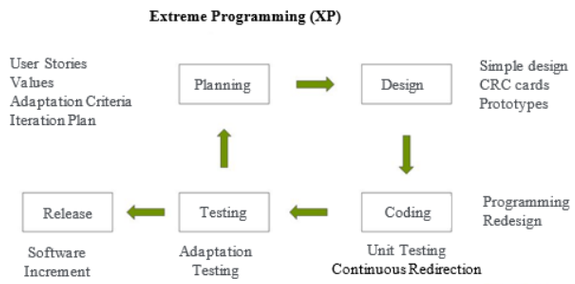


Figure 1
Title: XP Methodology
Source: (Rodriguez, 2022)

Planning

In this phase a comparative table was developed showing applications oriented to create 3D projects using AR technology, within them we analysed the license, the platform on which they work, advantages and disadvantages, minimum requirements: Unity, vuforia, spark AR, Lends Studio, Photoshop, Affinity photo, Blender.

After the analysis it was determined to use Matlab for mathematical applications and graphics, Unity and vuforia to implement 3D models, Lens Studio and Meta Spark Studio for AR interaction in social networks.

User stories were created, as in software development, it is essential to have a clear and structured guide for the integration of tools.

- Description of the process of loading the SDK file into the project.
- Integrate SDK into Unity.
- Image target implementation.
- Upload the 3D models.
- Generate the APK.

The correct configuration and generation of the APK in Unity is essential to ensure that the application can be distributed and installed on Android devices at a given time, complying with the standards and working as expected in the final environment.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

Design

3D graphics design.

Box 2

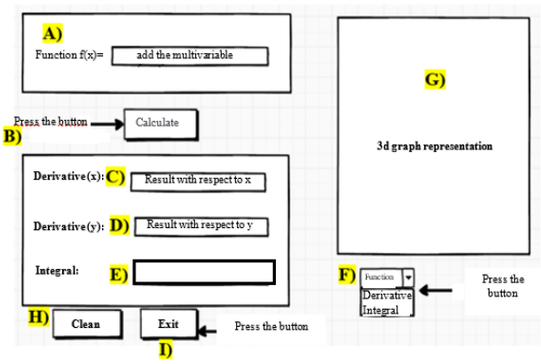


Figure 2
Title: Partial integral and derivative calculator

Source: Own elaboration, 2024

An application for calculating partial derivatives as a function of x, y and 3D graphics were modelled in preparation for SDK integration.

Unity 3D model designs.

Box 3

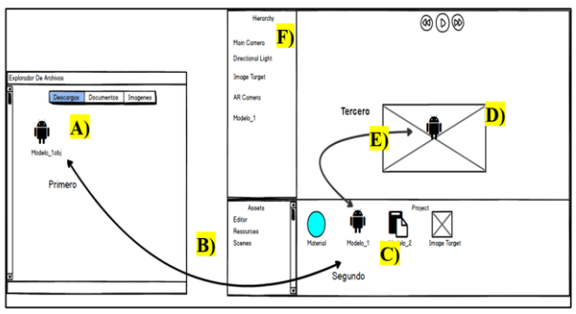


Figure 3
Title: 3D Unity Modelling

Source: Own elaboration, 2024

Workflow:

A. File explorer view, 3D models are found.
B. Drag model from file explorer to unity.
C. Model added to unity.
D. Model added to unity interface.
E. Image target which will be scanned to visualise the 3D model.
F. Application components.

Result display screen

Box 4

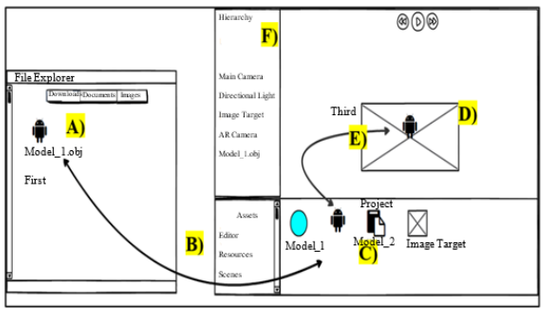


Figure 4
Title: 3D Modelling

Source: Own elaboration, 2024

Workflow:

A. Camera display.
B. Scan image target.
C. 3D model display.

Coding

In this phase, a complete installation manual has been developed to provide a step-by-step guide for the installation of the Unity graphics engine. This manual also includes the integration of the Vuforia SDK, an advanced tool that allows access to a robust set of features and functionalities.

Thanks to the implementation of Vuforia in Unity, it is possible to enhance the development of applications that require the visualisation of 3D models using Augmented Reality (AR) technology, facilitating the creation of interactive and immersive experiences.

AR glasses with Lends Studio, a virtual augmented reality glasses creator has been developed using Lens Studio, designed to deliver a personalised and engaging experience. During the creation process, tools such as Affinity Photo were used for filter editing and texture adjustment, which were then exported to Lens Studio. The project included downloading lens models from Sketchfab, which were imported and adjusted in Lens Studio to perfectly fit the user's face.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

To try on the lenses, it is necessary to use the Snapchat app, which is downloaded to the mobile phone, allowing an immediate and realistic visualisation of the lens models. It is an idea for a customer to try out how they would look with this product.

Testing

A checklist was created detailing the essential steps for the development of an augmented reality (AR) application using Unity and Vuforia. Key aspects such as the installation of the Unity graphics engine, the incorporation of the Vuforia SDK, and the implementation of 3D models and Image Targets are evaluated. In addition, the correct functionality of the application is verified in terms of camera permissions, Image Targets detection and 3D model visualisation. Each element is reviewed to ensure compliance, allowing to document whether the requirements have been met and to record relevant observations that may arise during the development process.

Release

The applications that were realised with the AR Technology creation and visualisation tools are essential to support industries in attracting the attention of the general public, as well as in the educational field.

Results

As a result of this project, three aspects were focused on, the first one was to make sure that the students had knowledge about this technology, so numerical, hand-drawn and graphical activities were carried out to make them understand the basic knowledge. In addition, a Vuforia with Unity manual was developed from installation to the creation of 3D models and APKs.

As a second aspect, objects were designed and developed in AR in pairs, as the sub-academy decided that in this way it would support micro-enterprises in the region, with a transversal and integrative project that would be scaled throughout the four-month periods, thus ensuring

- The system conditions: correctly installing the Unity graphic engine, the incorporation of the vuforia SDK, the incorporation of the Image Target and the incorporation of the 3D Model.

- AR element designs were created: images in PNG or JPG format were imported, the quality of the images was analysed and the incorporation of the image into the Image Target was analysed.

- In terms of functionality: ensured that permissions were granted to access the camera and that the application would detect the Image Target via the device's camera; determined that the application would display the 3D model.

- Coding: In coding it was important to consider that the platform was Androi, configure the minimum Api for the operation of the application, create the application installer (APK).

The third point was to ensure that students understood the application and use of AR as part of their professional training and the added value in their projects, the following activities were carried out:

- Students taking the subject multivariable calculus will be able to enhance the learning of complex concepts through interactive visualisation of 3D graphics.

- Support education and training through simulations and visual tools that improve knowledge retention.

- Offer the possibility to interact with products tailored to individual preferences.

- Attract and maintain user interest through immersive visual experiences.

- Create unique experiences that differentiate brands, using emerging technologies.

- Provide tools that allow ideas to be explored and visualised more effectively.

- Develop new ways of interacting with content, enhancing the user experience.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

- Develop new ways of interacting with products and services, differentiating market offerings.

A project was carried out in the MATLAB tool in which a 3D surface graph was generated using the 'x', 'y', and 'z' matrices with the 'surf' function, which creates a three-dimensional mesh representing the surface defined by these points. It then exports this 3D model to an STL file with the name 'parabolic_model.stl', using the 'stlwrite' function, which is useful for 3D printing applications or CAD software. Finally, it saves the generated graph image as a PNG file named 'graph_surface.png' using 'saveas', allowing the result to be visually documented. This process ranges from viewing and exporting the 3D model to generating a static image of the graphic.

Box 5

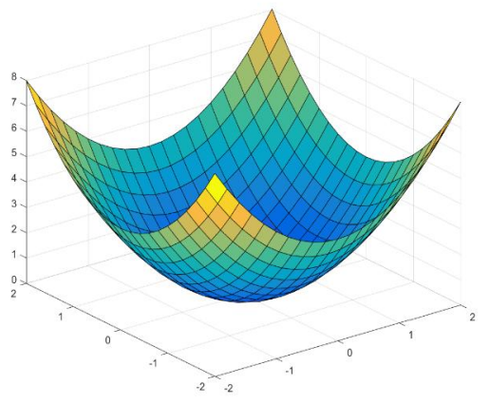


Figure 5
Title: Graphing in Matlab

Source: Own elaboration, 2024

As you can see, the image is scanned and as a result the 3D model is visualised by integrating Vuforia with Unity.

Box 6

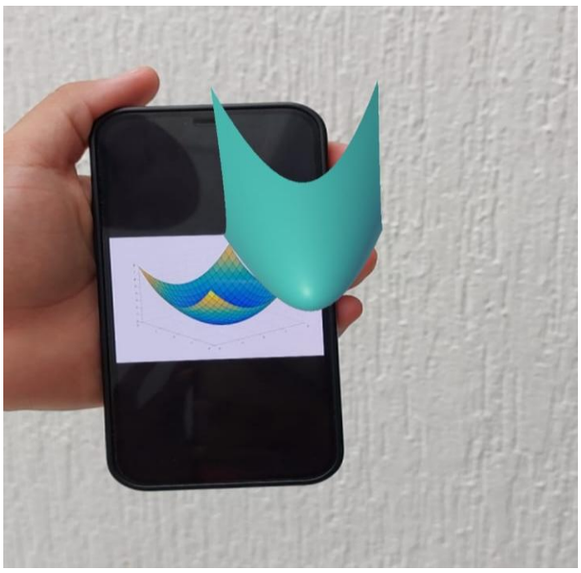


Figure 6
Title: Graphing in Matlab using Vuforia with Unity

Source: Own elaboration, 2024

Another outstanding application was for students to visualise how classroom knowledge using AR technologies can be applied to product sales, offering potential customers an experience closer to the reality of the product being offered.

a) The first team designed a website for a bakery in the region and as can be seen using Unity and Vuforia the customer's shopping experience was improved.

Box 7

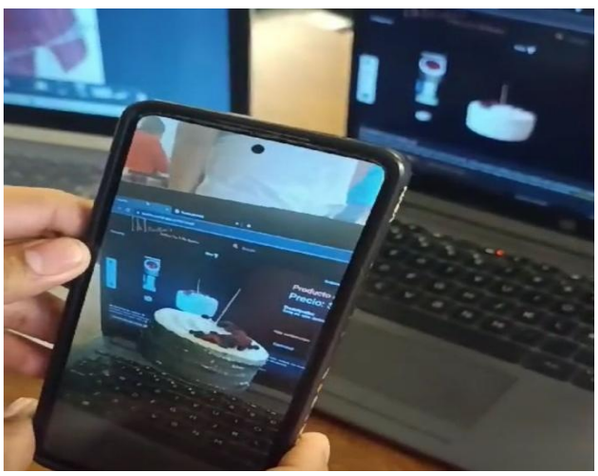


Figure 7
Title: Visualisation result of 3D model of pastry shop using Vuforia with Unity

Source: Own elaboration, 2024

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

b) Another team developed as a project a website for the sale of computer equipment and applied augmented reality in the following way.

The software made it possible to show computer equipment accessories modelled in 3D.

Box 8

Figure 8

Title: 3D mouse model visualisation result using Vuforia with Unity

Source: Own elaboration, 2024

Box 9

Figure 9

Title: Visualisation result of 3D model visualisation of hearing aids using Vuforia with Unity

Source: Own elaboration, 2024

c) This team models products for a gift shop.

Box 10

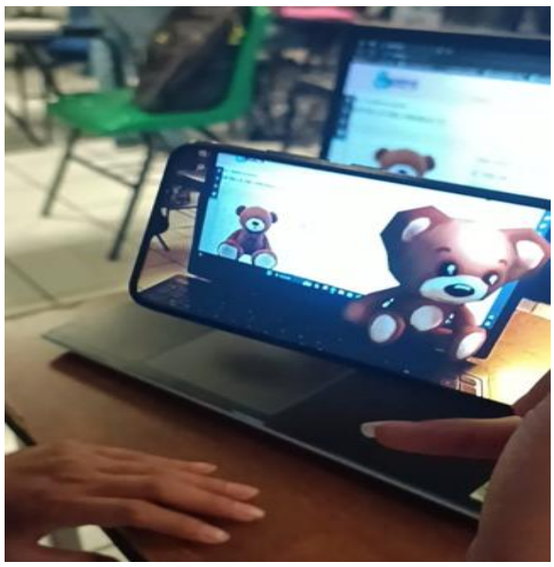


Figure 10

Title: Result of 3D Model Visualisation using Vuforia with Unity

Source: Own elaboration, 2024

Integrating Vuforia in Unity allowed the creation of augmented reality (AR) applications for mobile devices in this project the Android operating system was used, tests were conducted to determine how Vuforia works in Unity using Image Targets and 3D Models, an installation manual was developed focused on beginners so that they can integrate their knowledge, practical problem solving, interactivity and meaningful learning.

Conclusions

New applications and new ideas to be implemented emerge practically every day and this innovative force will grow with wearable devices. To get an idea, a search in Google's Android application repository (playStore) for the term augmented reality returns more than two hundred different applications and rising almost every day. The motivational elements of the use of the technology are now sufficiently proven to be beyond dispute and many authors argue that AR technology actually serves to improve educational practice and students' understanding of certain aspects of reality.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

It has also been used to provide practice to learners (medical applications) that would otherwise be impossible to provide with real subjects.

The world of marketing and advertising is no stranger to this technology and as an example we can see how the multinational furniture company IKEA has launched its catalogue with AR since 2014.

This work shows how the combination of knowledge and technology can change the perspective of the application of AR in local commerce and in any MSME, as well as offering students a way to visualise not just numbers but knowledge applied to the real world. It focused on the installation and configuration of the Unity graphics engine and the acquisition of Augmented Reality (AR) skills for application in industries such as education and product marketing. The Vuforia SDK, essential for developing AR-based applications, was also integrated. The implementation of these technologies offers significant added value, as their use is not yet widespread in both sectors, making them a visually appealing tool with high innovative potential. In addition, MATLAB was installed and interfaces were developed to efficiently calculate and graph results, facilitating the visualisation and analysis of complex data, essential for informed decision-making and process optimisation in various areas.

During the planning phase, extensive research was carried out to select the best tools for AR. MATLAB was chosen for the creation of 3D mathematical graphics because of its powerful graphics engine, while Unity, together with Vuforia, was selected for the development of AR applications because of its image recognition and digital element overlay capabilities. Lens Studio and Meta Spark Studio were chosen to create AR experiences in social networks. In the design phase, detailed mockups were created in Balsamiq to visualise the structure and flow of the application, anticipating challenges and aligning the visual aspects with the technical requirements of the project.

During coding, several applications were integrated into Unity and a detailed manual was developed for the installation and configuration of Unity and Vuforia, including functional testing. In addition, an interactive quiz application and an interactive filter were created in Meta Spark Studio. In the testing phase, the correct installation and configuration of Unity and Vuforia was evaluated, verifying the integration of Image Targets and 3D models, the configuration for Android, and the generation of the APK, ensuring a smooth user experience. Applications developed with AR offer significant value in education and industry, facilitating learning through interactive visualisations and customised simulations, and differentiating brands in the market.

During the tests, 60 students from the Information Technology course were involved, and it was undoubtedly an experience that allowed for a better relationship between numbers, products, customers and technology.

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.

Authors' contribution

Del Carmen-Morales, Yucels Anaí: Contributed research idea, project management, coding of AR applications and instrument design for testing.

Del Carmen-Morales, Heidi: Participated in the design phase and selection of elements to be coded to make the 3D models.

Felipe-Redondo, Ana María: Participated in the planning phase, which included academic meetings, integration of work teams and contact with MSMEs in the region.

Juárez-Castillo, Efrén: his specialisation in artificial intelligence and programming strengthened the fulfilment of the objectives and the feedback on the tests.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

Availability of data and materials

The data, results and information collected are available for consultation upon request to the corresponding author.

Funding

This research did not receive any funding, but was carried out with equipment and resources from the CATI Academic Team in Information Technology.

Abbreviations

List abbreviations in alphabetical order.

QR	Rapid Response Code
CATI	Academic Body in Information Technologies
CAD	Computer Aided Design
2D	Two-dimensional
SDK	Software development kit
MATLAB	Matrix laboratory
SLAM	Simultaneous localisation and mapping
B2C	End market
Mipymes	Micro, small and medium enterprises.
APK	Android application package
XP	Extreme programming
POIs	Points of Interest
AR	Augmented Reality
GPS	Global Positioning System
iOS	iPhone operating system
3D	Three-dimensional
UTHH	Technological University of Huasteca Hidalguense

References

Background

ABI Research. (2022). *Augmented Reality Total Market Value Will Surpass US$140 Billion in 2025*.

FORBES. (2021). *Una nueva forma de comprar: la Realidad Aumentada*.

(AMVO), A. M. (2021). *Estudio sobre venta online en México 2021*.

Retail Perceptions. (2018). Outstanding AR Experiences in the Retail Sector.

Fundamentals

Amaya, L., Barón, C., Bautista, J., Calderon, D., & Toores, A. (2021). *Wikitude y la realización de una aplicación de Realidad Aumentada*.

Barroso, J., & Gallego, Ó. (2016). *La realidad Aumentada y su aplicación en la educación superior*.

Béjar, V., Valenzo, M., Madrigal, F., Madrigal, S., & Montesinos, O. (2022). *Comercio electrónico y hábitos de los consumidores durante la pandemia por COVID-19 en México*.

Reyes, J., & Soberanes, A. (2022). *Diseño para incorporar realidad aumentada en el proceso de venta*.

Rigueros, C. (2017). *La realidad aumentada: lo que debemos conocer*.

Support

Cabero, J. (2018). *La realidad aumentada como herramienta educativa.*

De la Horra, I. (2017). *Realidad Aumentada, una revolución educativa*.

Díaz, B. (2016). *Realidad Aumentada en la educación*.

Vuforia Engine. (2024). *Virtual Scene Scale Factor in Unity*.

Vuforia Studio. (2024). *Centro de ayuda de Vuforia Studio*.

Diferences

Maquilón, J. (2017). *La Realidad Aumentada (RA). Recursos y propuestas para la innovación educativa*.

Morejón, S. (2023). La realidad aumentada como herramienta de marketing.

Rodriguez, M. (2022). *Metodología para el desarrollo del sistema Web para la gestión de los programas de maestría del Instituto "Pedro Kourí"*.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

Journal of Architecture and Design 8[19]1-13: 40819113
Article

Discussions

Prendes, C. (2015). *Realidad Aumentada y la educación: Experiencias practicas*.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Del Carmen-Morales, Yucels Anaí, Del Carmen-Morales, Heidi, Felipe-Redondo, Ana María and Juárez-Castillo, Efrén. [2024]. Augmented reality in the educational context for the digitalization of products and mathematical applications. Journal of Architecture and Design. 8[19]-1-13: e40819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.1.13

Journal of Architecture and Design 8[19]1-13: 50819113
Article

Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx.

Diagnóstico de la infraestructura accesible con énfasis en movilidad, de las instituciones educativas y de gobierno. Ciudad Valles, S. L. P. Mx.

Zapata-Padilla, Néstor Juan*[a] & Turrubiates Flores, Héctor Omar[b]

[a] Universidad Autónoma de San Luis Potosí • LRB-7765-2024 • 0000-0003-3367-3589 • 898332
[b] Universidad Autónoma de San Luis Potosí • JXX-6131-2024 • 00000-0002-6819-0598 • 203993

CONAHCYT classification:

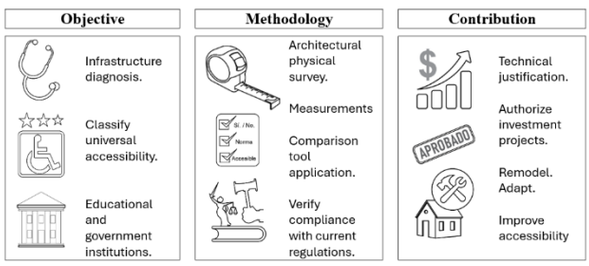
Area: Humanities and Behavioral Sciences
Field: Sciences of arts and letters
Discipline: Architecture
Subdiscipline: Urbanism

https://doi.org/10.35429/JAD.2024.8.19.5.13
History of the article:
Received: January 13, 2024
Accepted: December 31, 2024

* ✉ [evaperez@utch.edu.mx]

Abstract

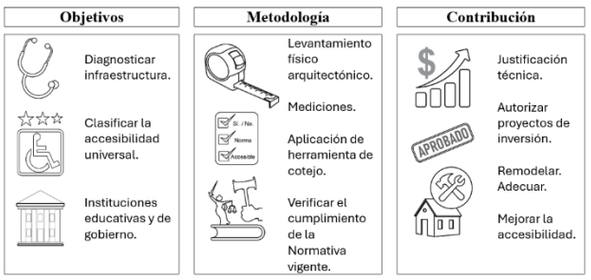
This document is to promote the citizens interest through parent associations, urban sector improvement committees; educational and governm institutions heads; to participate in the first Ranking about accessible infrastructure of the schools and government buildings. The construction elements are analyzed at the time that may lead establishment of indicators to identify opportunity areas to Institutions; with a technical justification aligned at current standards; can support urban-architectural intervention, remodeling and expansion projects, which they can participate for obtain financial support from government programs or private initiatives.



Infrastructure, Indicators, Urban

Resumen

Uno de los alcances que pretende el presente documento es propiciar el interés de la ciudadanía a través de comités de mejora de sectores urbanos; a las representaciones o titulares de instituciones educativas e incluso, a decisores públicos; a involucrarse de forma directa en la primera categorización del nivel de infraestructura accesible de las Instituciones educativas y de Gobierno, en donde se analizan las condiciones existentes de los inmuebles al momento que pueda derivar en la definición y establecimiento de criterios e indicadores suficientemente pertinentes para identificar las áreas de oportunidad en donde las Instituciones; con una justificación técnica alineada a las normas vigentes; puedan respaldar los proyectos urbano-arquitectónicos de intervención, remodelación y ampliación, con los que pueden participar y obtener apoyo económico de los programas gubernamentales o de la iniciativa privada.



Infraestructura, Indicadores, Urbanismo

Citation: Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.

Introduction

The study of the legal framework in force in the field of accessibility and mobility is considered essential, so the starting point is the consultation and interpretation of the General Law for the Inclusion of Persons with Disabilities, a law published in the Official Gazette of the Federation (DOF) on 30 May 2011, whose last amendment dates from 14 June of this year: 2024 (Mexico, G. F.., 2024) and its regulation, which was published in the DOF on 30 November 2012 and which, curiously, has not been reformed, let alone updated at the date of the presentation of this dossier (México, G. F., 2012), which indicates a lack of concern on the part of the legislator with federal competence in this regard. The Ley de obras públicas y servicios relacionados con las mismas, published in the DOF on 4 January 200 and last amended in the DOF on 20 May 2021 (México, G. F., 2021), is studied. In this sense, the Federal District Building Regulations (Mexico City, G. F., 2024) which, prior to the constitutional reform published on 29 January 2016, where various provisions of the Political Constitution of the United Mexican States were declared reformed and repealed with regard to the political reform of Mexico City, thus creating the federal entity Mexico City (CDMX), was applicable at the federal level and established precepts to be consulted and followed by the different federal entities. At the state level, the State of San Luis Potosí, the Law and its Regulation of public works and related services of the State of San Luis Potosí (Gobierno del Estado de San Luis Potosí., 2021 and G. E. de San Luis Potosí., 2015) empowers municipalities to regulate in this matter.

In this tenor, the provisions of operating manuals developed, implemented, and of course, legitimised by decree of the Federal Executive, by government institutions such as the manual of technical standards of accessibility of Mexico City (Gobierno de la Ciudad de México, 2016) which is based on anthropometric measurements and technical aids that make possible the adequate movement and activities of persons with disabilities and is the result of a collective and long-term task that leads to an evolutionary process of regulation and development of design and construction standards, which seeks to create an accessible and inclusive environment for the benefit of all sectors of the population.

When analysing the basic bibliography; specifically technical manuals concerning Universal Accessibility and mobility infrastructure, it is identified that the construction specifications are similar (SECTUR,2018; SEDUVI,2016; INIFED,2022; IMSS, 2016; IMSS,2000; CONAVI, 2017; G.F. de México, 2011 Secretaria de Economía, 2015 and 2016). From the analysis of the regulations and manuals, it can be seen that some of them, more than others, handle particular construction specifications, all aligned with the Manual of Technical Standards for Universal Accessibility of Mexico City; consequently MNTAUDF; base manual of the design that was carried out in 2018 (Zapata, 2018) for the first proposal of the assessment tool for accessible spaces with an emphasis on mobility.

Objective

To evaluate, in accordance with current regulations, the architectural infrastructure of educational and Government Institutions, which are within the urban area of Ciudad Valles, S.L.P. to assess the degree of integration and relevance to the needs of mobility and humanisation, with the intention of generating a diagnosis in technical report format, which allows to assess the areas of opportunity, as a basis to support the development of adaptation, restructuring and remodelling projects, so as to eliminate physical barriers and improve movement within the facilities. This is in accordance with article 9 of the Convention on the Rights of Persons with Disabilities, which states that States Parties shall identify and remove obstacles and access barriers, which shall apply, inter alia, to buildings, public roads, transportation and other indoor and outdoor facilities such as schools, housing, medical facilities and workplaces (CNDH, 2010).

Objectives

The specific objectives of the research; those goals that when achieved will lead to the overall objective are as follows:

1. To design an evaluation tool aligned to the current standards on universal accessibility.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

2. To carry out a field visit to each educational institution in order to elaborate a comparative analysis based on the evaluation rubric vs. the measurements of the existing architectural elements.

3. Generate demonstrative graphs to present the results of the analysis.

4. Produce technical reports for each educational institution.

Hypothesis

Educational and government facilities need to improve architectural conditions to facilitate pedestrian mobility through the adaptation of horizontal and vertical circulations. When the architectural infrastructure is improved to meet the parameters of universal accessibility, the flow of people increases and improves, as well as increasing the scope of the service offered by the institution to attract human capital and users.

Problem

It has been detected that the architectural space of some educational and government institutions represents problems in terms of mobility and safety, especially for people with motor disabilities, children and the elderly, as well as for blind people. This is particularly evident at the entrances, which are made up of small squares and steps.

It is also observed that the circulation corridors lack properly designed ramps, stairs and elevated areas in most cases do not have handrails or curbs to safeguard people's safety. These aspects represent horizontal and vertical circulation problems for people, together with the need for ethical signs for a correct orientation and flow of people.

Justification

The benefit of the research is to generate a diagnosis in the form of a technical report for each participating institution, with the intention of collaborating in the technical justification for the approval of investment projects for the improvement of state and federal schools, with which it is possible to improve the image.

Remodel and recondition the urban-architectural infrastructure of the institution, improving mobility conditions, especially for people with motor, auditory and visual disabilities, as well as for the elderly. (De Miguel, 2015). Another benefit of the research is to contribute in a positive way, to eradicate the perception of the population about discrimination and the limited opportunities of access to education and job opportunities that people with disabilities have according to the results of the National Survey on Discrimination in Mexico (INEGI, 2022 and INEGI, 2014) are important points that should be addressed according to the National Program for the Development and Inclusion of Persons with Disabilities 2014-2018 (G.F. of Mexico, 2014).

Approach

This research uses a descriptive qualitative approach, based on the observation of a social phenomenon such as the difficulty of moving safely, easily and freely within educational and government institutions, in addition to the limited presence of users with motor disabilities within the architectural space; once the problem has been identified, the cause that originates it and the way to mitigate it is exposed under the criteria of the researcher. Observation, delimitation of the focal group, field visits, interviews, documentary and comparative analysis, creation of graphs to facilitate interpretation, presentation of results and the corresponding analysis are implemented.

Theoretical framework and methodology

Section A Tool design

Since 2018, the design of the evaluation rubric begins; a tool that has served to diagnose universal accessibility in urban architectural spaces, specifically for buildings and circulations; The purpose of this is to assess and expose the level of adaptability provided by educational and governmental spaces to the general public, with the understanding that Universal Accessibility goes beyond focusing its efforts on a vulnerable sector of the population with motor, hearing or visual disabilities, but rather, it focuses on expanding its scope, providing access to services, spaces, information and movement to the majority of the population. (SEDUVI, 2016)

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

Part of the purpose of creating the evaluation rubric is to have an objective, simple, accessible and clear way to know and interact with the technical construction specifications that most of the manuals describe, and that, according to the surveys applied, a large part of the managers, municipal authorities and those responsible for the institutions are unaware of, which is why to date, both in Mexico and in other countries manuals continue to be developed to improve the interpretation of the current regulations on universal accessibility (Boudeguer, 2010; ONCE. 2011).

The rubric is made up of eight headings broken down into 244 indicators or items as proposed in other research (Del Moral, 2004); all of these derived from the basic bibliography in addition to the analysis of the tools designed by other authors whose results have been satisfactory (Torres, 2011) and a summary table is presented below with the number of indicators considered for each heading.

Box 1

Table 1

Groups and indicators number

no.	Group	Indicator
1	Parking and Accessible route.	22
2	Pedestrian ramps and bridges.	37
3	Podotactile pavement and access.	38
4	Information module and stairs.	40
5	Stairlifts, platforms and elevators.	16
6	Drinking fountains and sinks.	27
7	Bathroom and urinals.	38
8	Signage.	26
	Indicators sum.	244

Source: Own elaboration.

Another of the characteristics added for interpretation are the five intervals on a scale of one to five, as opposed to the six intervals proposed by Ríos, 2018, to establish a diagnosis of accessibility, in which the following legends are adopted: High accessibility if it meets 80% or more of the indicators; Good from 60% to 80%; Medium from 40% to 60%; Low from 20% to 40%; and Not accessible below 20% of the indicators. From table 1, it is important to note that some indicators will not apply to certain Institutions or buildings, because the particularities are different; for example, for an Institution whose buildings have only one level; ground floor; the item Stair lifts, platforms and elevators does not apply.

The digital design of the evaluation rubric is presented in Annex A; links per item in Microsoft Forms questionnaire format, which also includes a general information form, a survey for the registration of participation, and a section for the request of the technical report.

Section B Managing participation

The management of access to government and educational facilities was always under the supervision and authorisation of the management staff or those responsible for the administration of the institutions:

1. personally by visiting the institutions and explaining the reasons and objectives of the research to the managers and those responsible. In this first option, given the fear of the managers about the results, it was always important to clarify that, to date, in most of the municipalities, the Manual of Technical Standards for Universal Accessibility of the Federal District is not mandatory, so that non-compliance does not represent any reprimand from the authorities of the Public Administration towards the institution. This also identifies a lack of knowledge about the application and scope of the MNTAUDF.

2. In a formal way, with a letter of invitation addressed to the administrative heads where the interest in their Institution to participate in the First Ranking of Universal Accessibility is expressed, in order to demonstrate and compare the level of their facilities with other Institutions. Participation can also provide them with some of the benefits described above.

Section C Fieldwork

Once access to the institutions is provided, the observation and data recording activity is carried out over a period ranging from two hours to approximately two days, the first day to carry out the observation, measurement and filling in of the rubric, and the second to verify and confirm the veracity of the information.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

The time is conditioned by the size of the Institution and the number of people who carry out the field activity. It is suggested to work with at least three people in order to carry out the activities properly.

The tools used are the following:

1. Checklists (Evaluation rubric in printed format to write down) 2.
2. Flexometer to measure short distances.
3. 30-metre tape for medium distances.
4. Distance meter for long distances.
5. Vernier for measuring diameters.
6. Bubble level to verify inclinations by means of squares to verify slopes.
7. Photographic camera to integrate evidence.
8. Computer equipment.
9. Creation of forms in the Microsoft Forms application.
10. Excel for data processing.
11. Word to integrate reports.

Section D Integration of technical reports

The collation tables were transcribed to the Microsoft platform, specifically forms were created in the Forms application with the intention of creating a digital backup of the information, in addition to facilitating the processing and analysis of the information through real-time graphs and later in Excel.

Finally, the last stage of the research, which is in the process of development, is to present the results in Ranking format, and to integrate them in the elaboration of the technical reports that will be sent to each of the participating institutions, hoping that they will be of help for future projects.

Results

The results of the research are presented in the order of the items, the participating institutions to date are three universities in which each of the buildings were studied independently, which is why the numbering is added to one decimal place; four middle schools, five elementary schools where one is secondary; four primary schools and finally, two government institutions; a total of 14 participating institutions and a grand total of more than 20 buildings evaluated.

The graphs of the results and the corresponding analysis are presented below; it is important to anticipate to the reader that the buildings of some Institutions that appear without information are because they do not require the facilities because they share them with other adjacent buildings; such as for example the sanitary services or the car park.

Figure 1 identifies the result corresponding to the item Parking and accessible route, where the Diagnosis is that six Institutions-Buildings have low Accessibility, four with A. medium, seven with A. good and five with A. high; this item is where the general results were the ones with the highest percentage of accessibility.

This is due to the fact that building regulations are mandatory and specify the number of vehicle parking spaces required for a building based on its function and size in square metres of construction, as well as the general characteristics of car parks; such as transverse and longitudinal slopes of vehicular lanes and parking spaces, minimum signage, configuration of curbs, widths of vehicular accesses, minimum widths of pavements and their height, as well as the percentage of transverse slope required for access ramps, and their transitions, if required.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

Box 2

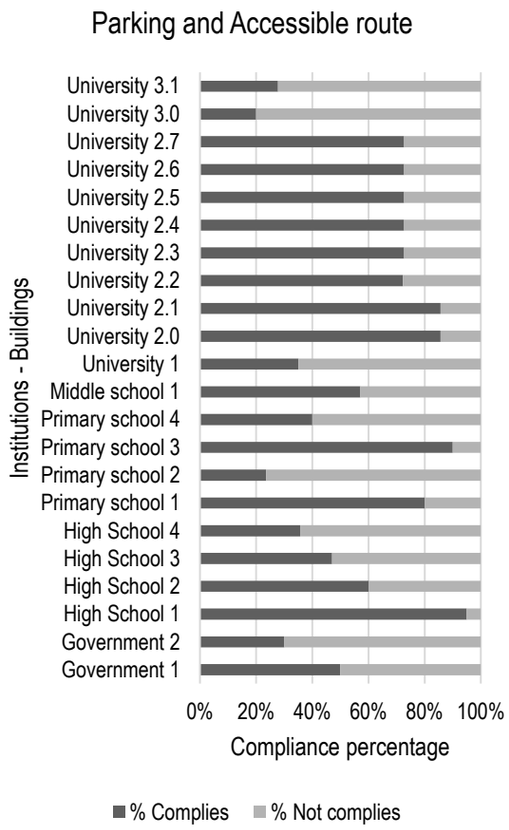


Figure 1

Parking and accessible route compliance results

Source: Own elaboration

Figure 2 shows the results of the item Ramps and overpasses, where the diagnosis is that only two Institutions-Buildings have High A., eight have Medium A., four have Low A., eight are not accessible; none has Good A.

In general, during the field visits, ramps were identified in more than 90% of the institutions, however, it is common that their characteristics do not comply with the recommended construction specifications.

From the above, it is observed that the topographical conditions where the buildings are located cause large vertical differences between the levels of the construction elements such as pavements, pavements, slabs and pavements, so that slopes of 6% to 10% generate very long developments to connect them, which implies steeper ramps or the replacement of ramps by stairs. For example; to climb a 15cm pavement with a 6% slope ramp, a considerable development with a length of 250cm is required.

The diagnosis of the Pavement, visual touch and accessibility item is shown in Figure 3; where the results show that 16 of the Institutions-Buildings are not accessible, only five were rated with A. Medium and one with A. Low.

Access being a key element for the buildings, the problem detected is that the architecture of most of them is composed of one or several slopes; this starting from the car park or pavement, therefore reaching the finished floor level implies a correct architectural urban design relationship between the car park, the accessible route, the approach area and the connections between the changes in level; the ramps or stairs; and the topography in many cases plays against us.

Box 3

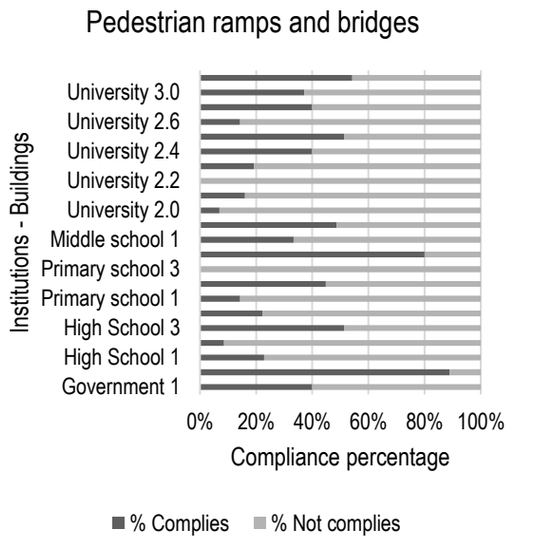


Figure 2

Pedestrian ramps and bridges compliance results

Source: Own elaboration

Lhe accessible route, stairs, ramps and accesses should also consider tactile or visual touch paving; to broaden the public that the building can serve, however, only one of the 22 elements studied had it; in the opinion of the respondents, it is an element that those responsible for the architectural design of the building do not consider important.

Regarding figure 4, of the Information Module and stairways item, eight elements are observed with A. medium, five with A. low, four with A. good, four with A. good, four Not accessible and only one with A. high.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

Box 4

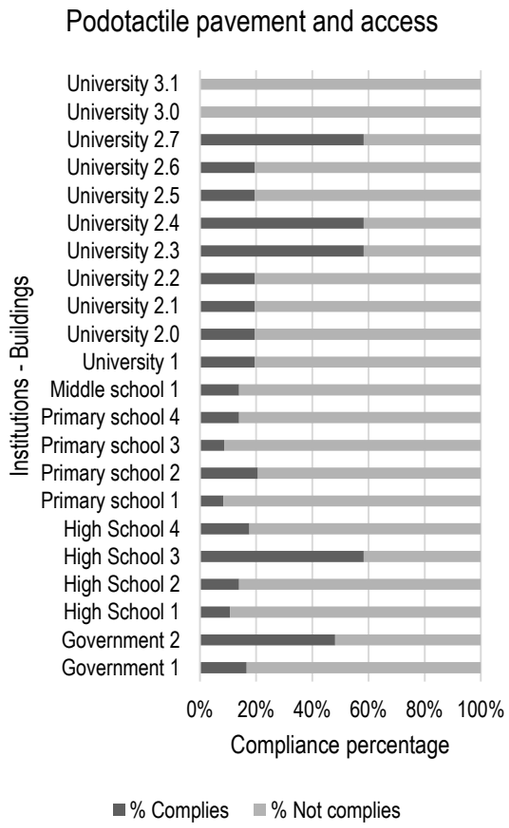


Figure 3
Podotactile pavement and access compliance results
Source: Own elaboration

Box 5

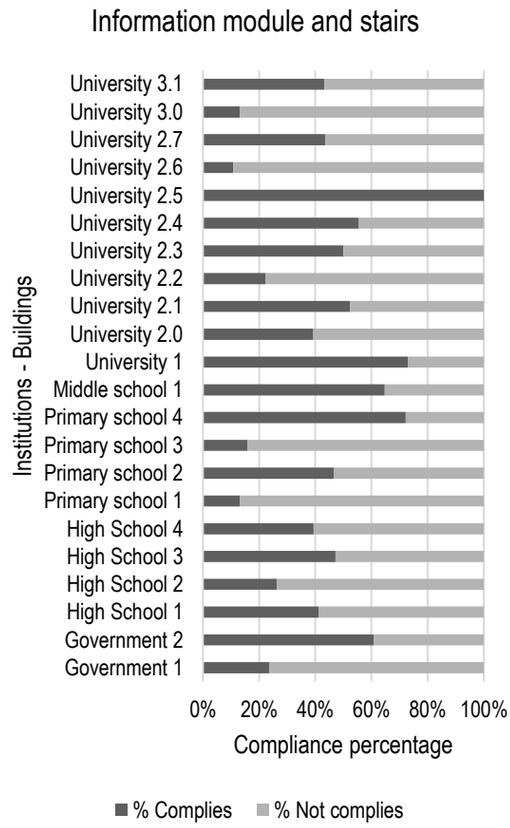


Figure 4
Information module and stairs compliance results
Source: Own elaboration

From the previous paragraph, on figure 4, it is observed in most cases that there is some type of stairs, despite the fact that some of the buildings evaluated only consist of one level, ground floor, which reinforces what has been described about the architectural design of the accesses and the complicated connections between the different levels of the construction elements, due to the complexity of the topography of the site.

Stairs, specifically the relationship between the depth of the tread and the height of the rise or riser, is very important for the architect or engineer, and is considered in the building regulations, however, some construction details are not, such as the diameter of the handrail, a specification that is found in some standards. With this it is possible to detect that part of the problem is the variety of guidelines that exist, which leads to investing more time in finding the necessary specifications for a better development of urban-architectural projects.

The result of the item of stair lifts, platforms and elevators is not shown, because none of the Institution-Buildings implements them. The strategy to avoid this is to eliminate the difficulty of climbing stairs, providing the service for people with disabilities on the lower floors of the buildings. As far as elevators are concerned and according to the building regulations, it is not necessary to implement them in buildings with less than four levels, so it does not apply to all the buildings that were observed and integrated in this research, where the tallest building that was evaluated is made up of the ground floor, level one and level two.

In Figure 5, on the Toilets and washbasins, the diagnosis is; one with high A., four with good A., six with medium A., four with low A. and six that are not accessible.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

For this item it is observed that, on average, the percentage of universal accessibility increases because the furniture itself is characterised by being designed with the principles of anthropometry and ergonomics, so the most common problem is the height of the installation, the omission of the inclination of the mirror and the particularities of the accessories; and in the case of washbasins composed of bars, the most common problem in addition to the above is the depth of the furniture.

Box 6

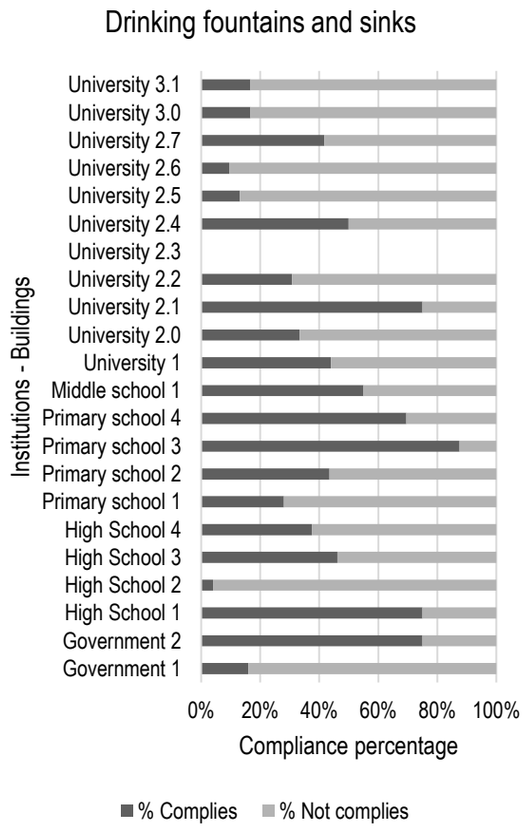


Figure 5
Drinking fountains and sinks compliance results
Source: Own elaboration.

In the case of the Bathrooms and urinals item, Figure 7 shows that the diagnosis is as follows: none with high A., none with good A., only two with medium A., seven with low A., and 12 are not accessible.

The cause that generates it, in the words of the researcher and based on some opinions of people, managers, administrators and specialists in the construction industry surveyed; is that the large number of details or specifications that are considered in the MNTAUDF; as point number one; go unnoticed by the specialists of architectural design; and as point number two, the greatest economic investment for the construction or remodelling of buildings is applied to the most important constructive or technological elements that form part of the public areas of the facilities, such as the façades, green areas and patios, computer rooms or laboratories; in this way, the private spaces destined for bathrooms and urinals are neglected.

Box 7

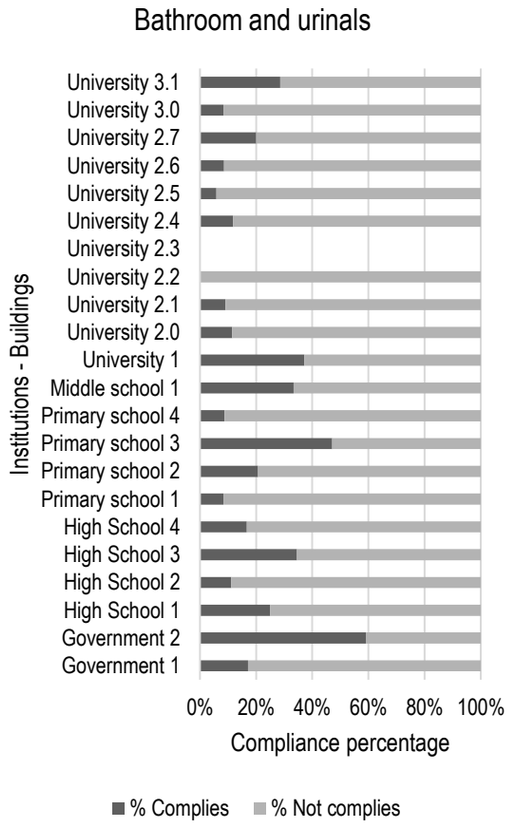


Figure 6
Bathroom and urinals compliance results
Source: Own elaboration

In the last item to be analysed, which corresponds to signage, the results can be seen in figure 8, where the diagnosis is encouraging, nine with A. good, five with A. medium, four with A. low, and four not accessible, none with A. high.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

For the last item, which corresponds to signage, it is considered that as it is a regulated item and exposed to supervision by other bodies such as Civil Protection, it retains an added value given the importance of safeguarding the safety of workers, students, teaching staff, management, administrative and maintenance staff, as well as the general public; therefore, educational and government institutions try to comply as far as possible with the specifications imposed. And with the intention of meeting the requirements, in some cases, it is observed that the signage is designed and manufactured by the staff of the same institutions.

Box 8

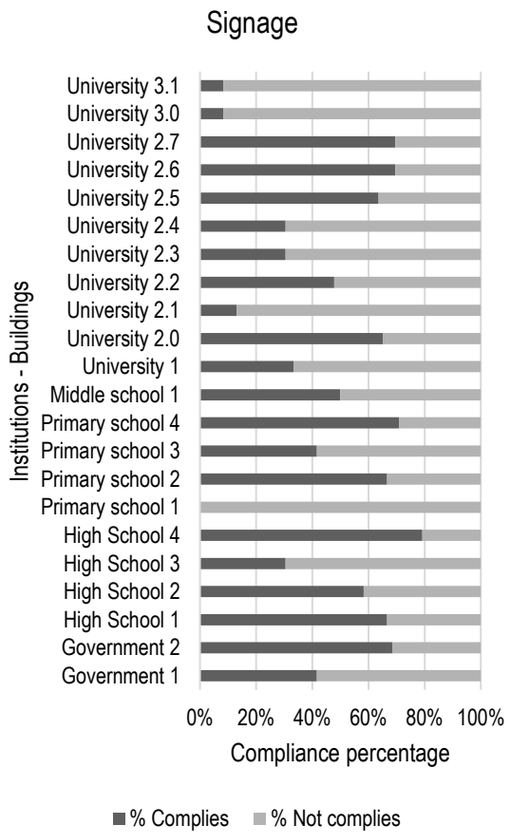


Figure 7
Signage compliances results
Source: Own elaboration

Conclusions

A relevant tool was designed and applied to diagnose the infrastructure in terms of universal accessibility with emphasis on pedestrian mobility, focused on the majority of the population.

The institution with the best results is evidently a decentralised public body and its main function is to attend to the public and families in vulnerable situations, street people, elderly people, people with disabilities, among others. Unique in having visual touch pavement.

Box 9

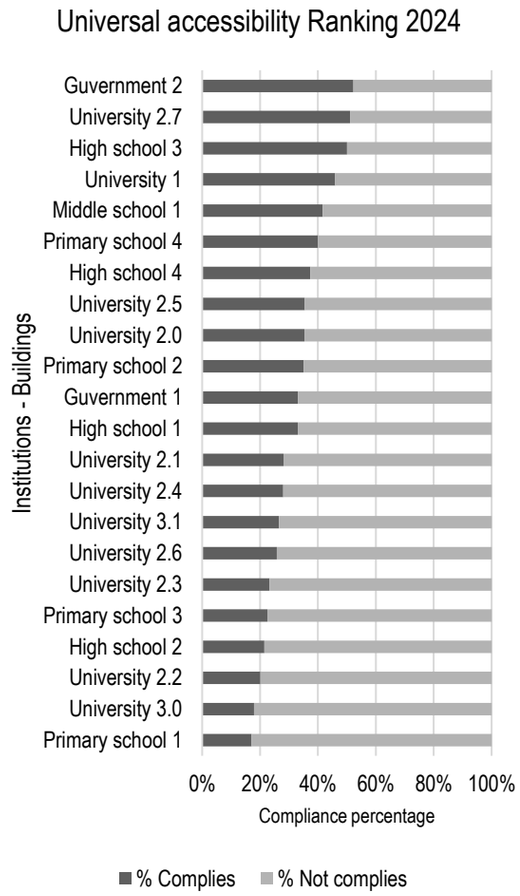


Figure 8
Universal accessibility ranking of educational and government institutions 2024
Source: Own elaboration

Figure 8 shows the Universal Accessibility Ranking of the participating Educational and Government Institutions, in which it can be seen that the average rating is 35% of the indicators; the maximum rating is 52%, the minimum 17%; so the average Universal Accessibility diagnosis is Low. The particular diagnosis can also be seen in table 2, where six Institutions-Buildings with medium accessibility, two not accessible and 14 with low accessibility are observed.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

Box 10

Table 2

Diagnosis of the accessible infrastructure of Educational Institutions and Government 2024

Ranking	Institutions - Buildings	Diagnosis
1	Guvernment 2	Average
2	University 2.7	Average
3	High school 3	Average
4	University 1	Average
5	Middle school 1	Average
6	Primary school 4	Average
7	High school 4	Low
8	University 2.5	Low
9	University 2.0	Low
10	Primary school 2	Low
11	Guvernment 1	Low
12	High school 1	Low
13	University 2.1	Low
14	University 2.4	Low
15	University 3.1	Low
16	University 2.6	Low
17	University 2.3	Low
18	Primary school 3	Low
19	High school 2	Low
20	University 2.2	Low
21	University 3.0	Not accessible
22	Primary school 1	Not accessible

Source: Own elaboration.

In the consultations carried out in the application of the surveys, it was identified that a large number of construction specifications described in the regulations and manuals are unknown to most of the directors and administrators of the participating institutions; they know of the existence of manuals, but not of their scope and particularities. In several educational institutions, the technical report resulting from the analysis will be very useful to highlight the problems and justify the need to improve the architectural urban space, also to support the change in the image of the facilities and to encourage the increase of the target public to which they provide services. According to some surveys, it is also detected that people with motor disabilities consider that the items of accessible route, ramps and parking are more important, while a proportional part thinks that the items of ethical signs and stairs are also an important part of the characteristics of an accessible building. In the opinion of the researchers, it is necessary to align and centralise the construction specifications of regulations, standards and manuals so that there is a clear bibliography for design and construction specialists to apply in projects.

Although the topographical conditions of cities and urban-architectural spaces make the application of certain elements difficult, it is feasible to establish, under certain circumstances, the obligatory application of the MNTAUDF in order to reduce physical barriers and improve social inclusion.

Annexes

Annex A. Links per item in Microsoft Forms questionnaire format:

1.
https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxUOURHQzJVOExGQUM0QjFCRVBRQkM4R1hFSi4u

2.
https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxUQ0E5WUpFSjVFMzU2TlpOWDJMNkVPUjVOSS4u

3.
https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxUMDdSMU45SDNRMUpaOVE2QzFVNko5N1JFOC4u

4.
https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxUQzdaQklJMUNCMU8xRVE2T1laSFQ4S1NaVS4u

5.
https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxUM1pETUhLU0JZTVRBUTdRWU41UUpYRTRPRy4u

6.
https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxUMDZOSjFKREZPMzFETlZOODU4QzlXRzVORi4u

7.
https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxUQ1JKV0pLVVlDWUY1NzRMRUdPR01KVDdaUC4u

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

8. https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxURDlQNFo2MUM3UFM5MzVKT0s4OVIyUFU5WS4u

9. https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxUOURPR0ZZV041UDNQTlBSV1dRR1A2SkJVQS4u

10. https://forms.office.com/Pages/ResponsePage.aspx?id=WBZoYC0PTkqq8W_V8tujP12t3iOilvdDipIyvBxBjOxUNkJZOE85N0dQUTk0U05TWFpDNjg2TUhRTy4u

Declarations

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

Zapata Padilla, Néstor Juan; Contribution with the idea, methodological process, creation of the indicator proposal according to the constructive specifications of the normative framework, data processing and interpretation, and integration of the information in the article.

Turrubiates Flores, Héctor Omar; Review of bibliography and analysis of the background of the current legal framework, for the drafting of the summary and introduction. Analysis of results.

Availability of data and materials

As stated in Annex A, the indicator rubric is available on the web and is open access. The editable file of the evaluation rubric in Excel format can be requested via email to the authors' email address. To assist in the interpretation and analysis of the results of this research, the information can be requested directly from the authors of this article and will be provided in editable Excel format.

Funding

The tools used in the field activities were financed with extraordinary resources derived from the FEPZH-UASLP linkage projects; coordinated by the principal investigator of the present study.

Acknowledgements

We are grateful for the collaboration of the 2021 and 2022 generations of the Bachelor's Degree in Architecture of the FEPZH of the UASLP, who have carried out field activities. They also provided important comments to expand and improve the criteria for observation and consideration of the indicators that make up the items.

Thanks are also due to the people who were interested in their institution's participation and were willing to provide all the necessary assistance. Sincere thanks to the Directors and Administrators of the educational and government institutions.

Abbreviations

A. Alta	Accessibility High.
A. baja	Low accessibility.
A. buena	Good accessibility.
A. media	Medium accessibility.
CONAVI	National Housing Commission.
CNDH	National Human Rights Commission.
DF	Federal District.
DOF	Official Journal of the Federation.
G. E.	State Government.
G. F.	Federal Government.
IMSS	Mexican Institute of Social Security.
INEGI	National Institute of Statistics, Geography and Information.
INIFED	National Institute of Educational Physical Infrastructure.
IMSS	Mexican Institute of Social Security.
MNTAUDF	Manual de Norma Técnica de Norma Técnica de Accesibilidad Universal del Distrito Federal.
NTCPA	Complementary Technical Standard of the Architectural Project.
S.L.P.	San Luis Potosí.
SECTUR	Ministry of Tourism.
SEDUVI	Ministry of Urban Development and Housing of the CDMX.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

References

Background

CNDH (2010). "Muestra-Diagnóstico Nacional de Accesibilidad en Inmuebles de la Administración Pública Federal". Comisión Nacional de los Derechos Humanos, México.

CNDH (2020). La Convención sobre los Derechos de las Personas con Discapacidad y su Protocolo Facultativo. México.

Gobierno del Estado de San Luis Potosí. (2023). Reglamento de construcciones del municipio de San Luis Potosí.

G. E. de San Luis Potosí. (2021). Ley de obras públicas y servicios relacionados con las mismas del Estado de San Luis Potosí.

G. E. de San Luis Potosí. (2015). Reglamento de la Ley de obras púbicas y servicios relacionados con las mismas del Estado de San Luis Potosí.

Gobierno Federal de México. (2014). Programa Nacional para el Desarrollo y la Inclusión de las Personas con Discapacidad 2014-2018, publicado en el Diario Oficial de la Federación el 30 de abril de 2014.

México, G. F. (2024). Reglamento de Construcciones para el Distrito Federal. México, D.F.: Gaceta Oficial del Distrito Federal.

Gobierno Municipal de Ciudad Valles. (1999). Reglamento de construcción para el Municipio de Ciudad Valles S L P.

INEGI. (2022). Encuesta Nacional sobre Discriminación (ENADIS) 2022.

INEGI. (2014). La discapacidad en México, datos al 2014. México, D.F. Instituto Nacional de Estadística y Geografía.

México, G. F. (2024). Ley general para la inclusión de las personas con discapacidad. México, D.F. Diario Oficial de la Federación.

México, G. F. (2012). Reglamento de la Ley general para la inclusión de las personas con discapacidad. México, D.F. Diario Oficial de la Federación.

México, G. F. (2021). Ley de obras públicas y servicios relacionados con las mismas. Diario Oficial de la Federación.

ONCE. (2011). Manual de accesibilidad para técnicos municipales. Madrid: Fundación ONCE.

De Miguel, M. (2015) La necesaria evaluación de la accesibilidad de espacios culturales: un caso práctico. La ciudad accesible. Revista científica sobre accesibilidad universal. Número 5. ISSN 2174-9167.

Basics

CONAVI. (2017). Código de edificación de vivienda. Gobierno Federal de México.

Secretaria de Economía. (2015). Norma mexicana nmx-r-084-scfi-2015 escuelas – levantamiento de datos para el diagnóstico de la infraestructura física educativa – directrices y requisitos.

Secretaria de Economía. (2016). Norma mexicana nmx-r-090-scfi-2016 escuelas - elementos para la accesibilidad a los espacios de la infraestructura física educativa – requisitos.

Support

IMSS. (2000). Normas para la accesibilidad de las personas con discapacidad. México, D.F. Instituto Mexicano del Seguro Social. Tercera edición.

IMSS. (2016). Criterios de proyecto arquitectura para la accesibilidad de las personas con discapacidad. Instituto Mexicano del Seguro Social. Tercera edición. ISBN 968-824-762-6. Paseo de la Reforma 476. México, D.F.

G.F. de México. (2011). Normas técnicas complementarias del Reglamento de construcciones para el Distrito Federal. Gaceta Oficial del Distrito Federal.

SEDUVI. (2016). Manual de normas técnicas de accesibilidad. México, D.F.: Secretaria de Desarrollo urbano y vivienda.

INIFED. (2022). volumen 3. habitabilidad y funcionamiento. tomo II Accesibilidad.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

SECTUR, (2018). Guía de recomendaciones de diseño universal para el sector turismo.

Differences

Boudeguer Simonetti, A., Prett Weber, P., & Squella Fernández, P. (2010). Manual de accesibilidad universal. Santiago de Chile. Gobierno de Chile.

Del Moral, C., (2004). Modelo de Verificación de la accesibilidad en los edificios de concurrencia pública, de usos docente y residencial colectivo hotelero: Sistema de cualificación de los espacios para una mejor percepción y comprensión de su configuración arquitectónica y funcionamiento. Tesis doctoral. Universidad de Granada. ISBN: 978-84-338-4458-3

Ríos Trujillo, Enrique Uriel (2018). Diseño de un instrumento para la evaluación de la accesibilidad universal. Instituto Tecnológico de Colima, México. Ingeniería, vol. 22, núm. 3, pp. 1-11. Universidad Autónoma de Yucatán.

Discussions

Torres Holguín, J. (2011). Propuesta metodológica para la construcción de una guía de evaluación accesible en el medio físico en instituciones educativas Sedes muestra Universidad Nacional de Colombia: estudio de caso: documento diagnóstico estado actual y recomendaciones de accesibilidad en la Universidad Nacional de Colombia (DDRASUN). Universidad Nacional de Colombia.

Zapata Padilla, Néstor Juan. (2018). Accesibilidad universal en la UASLP-UAMZH. Tlatemoani Revista académica de investigación. Eumed.net. no. 29 – diciembre 2018. España. ISSN: 19899300.
.

ISSN: 2531-2162
RENIECYT-CONAHCYT: 1702902

Zapata-Padilla, Néstor Juan & Turrubiates Flores, Héctor Omar. [2024]. Accessible infrastructure´s diagnosis with mobility emphasis, about educational and guberment institutions. Ciudad Valles, S. L. P. Mx. Journal of Architecture and Design. 8[19]-1-13: e50819113.
DOI: https://doi.org/10.35429/JAD.2024.8.19.5.13

Journal Architecture and Design 8[19]1-9: e60819109
Article

Lighting design proposal for the facade of an historic art building

Propuesta de diseño lumínico para la fachada de un edificio de arte histórico

Zavala-Hernández, Karina[a], Ortega-Lazcano, Jesús Benjamín[b], Demesa-López, Francisco Noé[c] and Serrano-Arellano, Juan*[d]

[a] TecNM/IT de Pachuca • 0000-0002-9051-4520
[b] TecNM/IT de Pachuca • 0000-0002-9051-2039
[c] TecNM/IT de Pachuca • 0000-0001-7197-6017
[d] TecNM/IT de Pachuca • F-1660-2013 • 0000-0002-7875-0106

CONAHCYT classification:

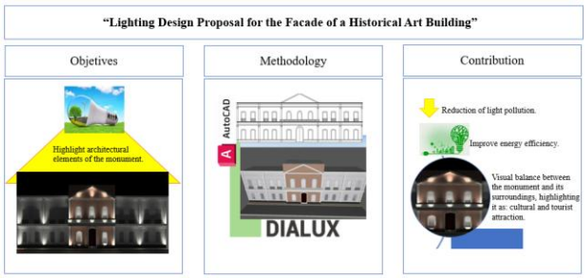
Area: Engineering
Field: Engineering and Technology
Discipline: Mechanical Engineering
Subdiscipline: Energy

https://doi.org/10.35429/JAD.2024.8.19.6.1.9
History of the article:
Received: September 08, 2024
Accepted: December 30, 2024

* ✉ [juan.sa@pachuca.tecnm.mx]

Abstract

This article details a lighting proposal for a historic monument, which includes two main systems: one focused on the building's façade and another on the sidewalk surrounding it. The aim is to highlight the most emblematic architectural elements through a uniform design that avoids visual distortions and minimizes the impact on the structure, using sustainable technologies to reduce light pollution and ensure the preservation of the building. Likewise, the sidewalk lighting is designed to improve the safety and comfort of pedestrians, integrating harmoniously with the façade design. This system seeks to maintain a visual balance between the monument and its urban environment, promoting its perception as a point of cultural and tourist interest.



Lighting, historic monument, architectural conservation

Resumen

El presente artículo detalla una propuesta de iluminación para un monumento histórico, que incluye dos sistemas principales: uno enfocado en la fachada del edificio y otro en la banqueta que lo rodea. Con el objetivo de resaltar los elementos arquitectónicos más emblemáticos mediante un diseño uniforme que evite distorsiones visuales y minimice el impacto en la estructura, utilizando tecnologías sostenibles para reducir la contaminación lumínica y garantizar la preservación del inmueble. Así mismo la iluminación de la banqueta se diseña para mejorar la seguridad y comodidad de los peatones, integrándose armónicamente con el diseño de la fachada. Sistema que busca mantener un equilibrio visual entre el monumento y su entorno urbano, fomentando su percepción como un punto de interés cultural y turístico.

Iluminación, monumento histórico, conservacion arquitectónica

Citation: Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan. Lighting design proposal for the facade of an historic art building. Journal of Architecture and Design. 8[19]-1-9: e60819109.

Introduction

Façades define the character of the building and fulfil various functions, whether formal, aesthetic or symbolic, thus reflecting the social and economic needs of the context in which they are located. Their surface as well as their design are influenced by the function of the building, the materials used, the location, the climate, the prevailing historical or artistic movements, as well as the sensibility of the owner or architect.

Lighting today plays an essential role in the plastic arts and, specifically, the lighting of façades and monuments makes it possible to recreate their architecture at night and achieve results of great beauty which may even be superior to those achieved with daylight, but which, in any case, if the lighting harmonises with their forms and atmosphere, will provide the delicate pleasure of discovering a new and surprising beauty, different from that obtained under sunlight, but no less interesting. This is why man has sought to illuminate his architectural works to enhance and magnify them (Casal, 1967), creating art.

Correct lighting can save at least 40 per cent of a building's total energy use, while bad practices can increase it by up to 90 per cent (CONUEE). The Taxco Charter, which regulates lighting in historic buildings, is a regulation to regulate proposals on night-time lighting of monuments and historic centres with the aim of contributing to the conservation, safeguarding and enhancement of cultural heritage from different approaches.

2. Theoretical framework

El Cuartel del Arte is an art gallery located in the historic centre of Pachuca de Soto, in the state of Hidalgo, Mexico. It is dedicated to presenting exhibitions on painting and sculpture by national and international artists.

In 1861, due to the Reform Laws, the religious ceased to occupy the Convent of San Francisco and from then on, it was given different uses: Practical School of Mines and general headquarters (today Art Headquarters), general state prison and municipal prison (today INAH Hidalgo Centre), and civil hospital (today Hidalgo Centre for the Arts).

In 1861, the Practical School of Mines was established in the building, which ceased to function during the French intervention. It was later put to various uses until, at the time of the Mexican Revolution, it was used as barracks and military offices for the garrison troops. On 18 September 1929, by presidential decree, it passed to the Secretariat of War, and on 17 October of the same year it was handed over to the Chief of Military Operations by the Federal Treasury Office. It became known as the 'Gabriel Hernández' Barracks. In 1984 the Regional Museum of History was inaugurated, this museum had three rooms. In the first one 'Raúl Guerrero G' there were fossil remains and prehistoric objects; this section showed the area of dominion that the Huastec and Aztec cultures had, as well as the archaeological discoveries in the area of Tula.

The second room 'Roberto Weitlaner', showed the colonial period, here the places of the catholic evangelization and artistic pieces of that historical period were observed. In the last room 'César Lizardi', wood carvings, wrought iron utensils, silver religious objects and oil paintings, among other artistic representations of the New Spain, were exhibited. In 2001, the Cuartel del Arte was created by the State Council for Culture and the Arts.

In 2010, the State Council for Culture and the Arts (CECULTAH), and the Support Programme for Cultural Infrastructure of the States (PAICE), remodelled the interior of the venue. In March 2018, work began on the refurbishment of the building, mainly on the façade, reopening on 13 March 2019.

In the need for cultural spaces and artistic expression to be projected to students, academics and alumni, the Ministry of Culture of the state decided to open the Cuartel del Arte for the first time, to exhibit the work of the creators from Hidalgo who study or who have graduated from the Institute of Arts (IA) of the Autonomous University of the State of Hidalgo (UAEH). Architecture The site on which the building stands has the shape of a rectangle and its main façade faces west. The main façade is covered with carved pink and white quarry stone and is formed by a door with a semicircular enclosure between two low windows with a very low arch. Three balconies on the first floor, preceded by a common quarry stone balustrade, correspond to its axes.

ISSN 2531-2162
RENIECYT-CONAHCYT: 1702902

Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan. Lighting design proposal for the facade of an historic art building. Journal of Architecture and Design. 8[19]-1-9: e60819109.
DOI: https://doi.org/10.35429/JAD.2024.8.19.6.1.9

On each side, on both floors, there are four windows, and the gable is crowned by a continuous parapet interrupted in the centre by a triangular pediment the length of the balustrade. The rear façade has large stone walls, in the centre a square bay, with two columns with a quadrangular base and capital; in this bay is the access door with a semicircular doorway; in the centre a balcony, and on each side two windows at the bottom and at the top.

2.1 General Requirements for the Lighting of Historic Monuments

Lighting projects for historic monuments should address the following key issues:

1. Research

It is essential to gather historical, graphic, photographic and documentary information about the building and its surroundings. This will require the consultation of specialised bibliography, as well as access to historical, photographic and cartographic archives to provide a comprehensive context.

2. Conceptual proposal for the intervention

It should include a detailed description of the characteristics of the property or historic area, including the movable assets, outstanding architectural or natural elements, and their stylistic, formal, urban and architectural particularities. It should also analyse their interaction with natural lighting, both indoors and outdoors, and their relationship with the immediate surroundings.

For public spaces, it is necessary to study the type and location of the main and secondary light sources, as well as the orientation and solar incidence. In addition, it is essential to define the objective of the intervention, specifying:

- Function and type of lighting.
- Levels and contrasts of light required.
- Technical means to be used.
- Characteristics and fixing systems of the luminaires.
- Location of the lighting points and the electrical distribution network, guaranteeing their safety.

Finally, a detailed analysis of the environmental impact of the proposal must be included.

3. Development of the proposal

Lighting tests will be carried out to verify the feasibility of the proposed design. These tests must have the prior authorisation of the competent bodies, ensuring that the integrity of the monument and its surroundings is respected.

2.2 Exterior Lighting

For the design and execution of the exterior lighting of a historic building, the following essential points should be considered:

1. Identification of the building and its surroundings

The characteristics of the historic building and its relationship to its immediate surroundings must be analysed to ensure a coherent design.

2. Uniform lighting

The project must ensure homogeneous lighting that allows the building to be appreciated as a complete unit, avoiding distortions or visual divisions.

3. Relationship with the surroundings

The proposal should highlight the monument without generating excessive contrasts that would cause lighting competition with the surroundings or ‘brightness creep’.

4. Independent lighting system

The lighting design should dispense with elements that require direct integration into the structure of the historic building.

4. Fixing and location of luminaires:

- It is prohibited to install luminaires on the façade that require drilling or boring into stone, wood or other materials of the property.

ISSN 2531-2162
RENIECYT-CONAHCYT: 1702902

Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan. Lighting design proposal for the facade of an historic art building. Journal of Architecture and Design. 8[19]-1-9: e60819109.
DOI: https://doi.org/10.35429/JAD.2024.8.19.6.1.9

- Luminaires and wiring on rooftops, decks or towers shall be installed using non-invasive methods of attachment that do not affect the structure or ornamental elements.
- Under no circumstances may ornamental areas (reliefs, sculptures, wall paintings, altarpieces, coffered ceilings) or structural elements with conservation problems be perforated.

6. Avoid visual distortions

No lamps should be placed on the floor, as they alter the perception of natural shadows and generate glare for pedestrians.

7. Detailed technical documentation

All fixing methods, wiring and equipment locations must be specified in drawings and diagrams included in the project. In addition, these must be supervised by a qualified technician and approved by the competent authorities.

8. Light pollution

The project must minimise the emission of light into the night sky to avoid light pollution.

9. Design for maintenance

The installation should provide easy access to all components for maintenance tasks, such as lamp replacement and equipment cleaning.

10. Maintenance manual

The project must include a manual detailing the scheduled maintenance tasks according to the lifetime of the lamps, together with specific instructions for handling and replacement, ensuring the correct operation of the system.

11. Regulatory compliance

The lighting system and its electrical installation must strictly comply with official safety regulations for electrical installations.

3. Methodology

1. Site reconnaissance and identification of construction materials.
2. Architectural survey in AutoCAD.
3. Modelling in DIALux software.

3.1. Site recognition and identification of building materials

Identification of the current construction, materials and lighting. Fig,1,2, 3 and 4. Façades of the Cuartel del Arte and current lighting.

Box 1

Figure 1

Cuartel del Arte, main façade. Extracted on 27/09/2023.*https://es.m.wikipedia.org/wiki/Archivo:Cuartel_del_Arte_en_Pachuca,_Hidalgo_10.jp.*

Box 2

Figure 2

Art Barracks, rear façade. Extracted on 27/09/2023 *https://es.wikipedia.org/wiki/Cuartel_del_Arte#/media/Archivo:Cuartel_del_Arte_en_Pachuca,_Hidalgo_07.jpg*

ISSN 2531-2162
RENIECYT-CONAHCYT: 1702902

Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan. Lighting design proposal for the facade of an historic art building. Journal of Architecture and Design. 8[19]-1-9: e60819109.
DOI: https://doi.org/10.35429/JAD.2024.8.19.6.1.9

Box 3

Figure 3

Current lighting of the Cuartel del Arte

Own Elaboration

Analysis of the materials used in the construction of the main façade to obtain their reflection coefficients, Table 1. Materials used in the construction of the main façade of the Cuartel del Arte. As can be seen, the building has white and pink quarry stone envelopes, wooden windows and doors.

Box 4

Table 1

Construction materials of main façade Art Barracks

Surface area of the Art Barracks.	
Materials	Reflection Coefficient %.
White in 60 x 30 cm blocks	Blank colour:70- 85. From the stone: .30
Wooden door	0.10 – 0.25
Stainless steel ironwork	0.5
Glass	1.50 – 1.66
Pink in 60 x 30 cm blocks	Pink colour 70 – 50. From the stone: 0.30

Own elaboration

3.2. Architectural Survey in AutoCAD

An analysis of the dimensions of the building was carried out, making an architectural survey to determine the necessary measurements for the lighting design. These measurements are represented using the AutoCAD programme, creating the elevation of the main façade, which is the part that is intended to provide better lighting.

Box 5

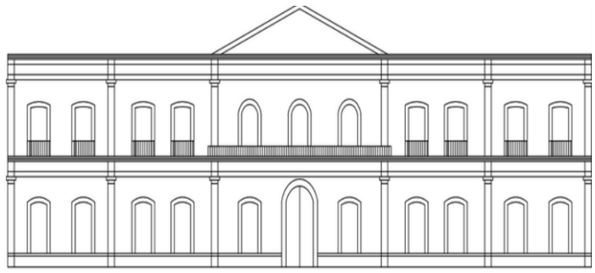


Figure 3

Elevation of the main façade of El Cuartel del Arte *Own Elaboration*

Box 6

Figure 5

Architectural plan of the main façade of El Cuartel del Arte *Own Elaboration*

Box 7

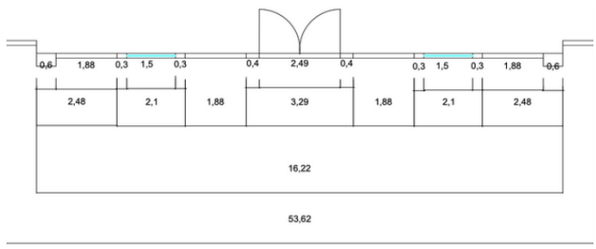


Figure 6

Architectural plan of the main façade with measurements of the El Cuartel del Arte

Own Elaboration

Box 8

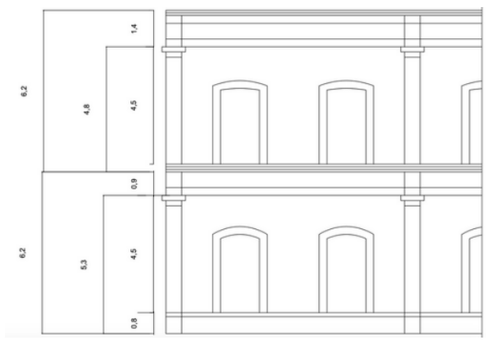


Figure 7

Elevation of the main façade with measurements of the El Cuartel del Arte.

Own Elaboration

ISSN 2531-2162
RENIECYT-CONAHCYT: 1702902

Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan. Lighting design proposal for the facade of an historic art building. Journal of Architecture and Design. 8[19]-1-9: e60819109.
DOI: https://doi.org/10.35429/JAD.2024.8.19.6.1.9

Box 9

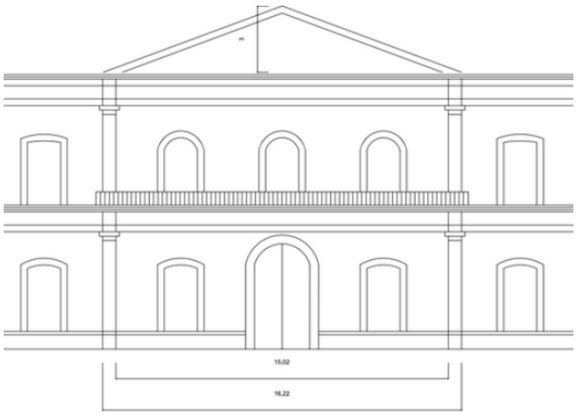


Figure 8

Elevation of the main façade (with measurements) of El Cuartel del Arte

Own Elaboration

3.3. Modelling in DIALux software

The DIAlux evo11 program is a software that allows the lighting design of any building and external areas. In the analysis only the lighting proposal for the façade is made, which is considered as a monument with the aim of showing off the façade and creating a different visualisation of what the building is on its own with natural light.

The lighting is diffuse, focused, framed, indirect or direct, with the aim of highlighting specific areas of the monument in this case, as well as its ornamentation, columns, bell towers, stained glass windows, among others. For this project, the pavement will be illuminated, which is the area where people go to the main entrance, arriving at it obliquely from the sides. The intention is to illuminate to cause impact from the approach to the construction, so a lighting design is made in this part of the Art Barracks in Pachuca de Soto, Hidalgo.

The DWG file is imported into the DIALux program, in which the proportion of the building can be seen, as well as the façade and the pavement, which is the part analysed for the lighting design, Fig. 9. DWG file in the DIALux program. Where the modelling begins and later the appropriate lighting fixtures will be installed according to the analysis that was made

Box 10

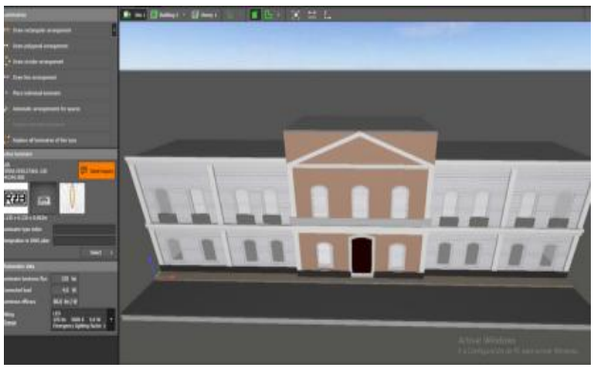


Figure 9

DWG file in the DIALux program

Own Elaboration

4. Proposal for the placement of luminaires according to the construction

The proposal is to illuminate the façade with lighting: diffuse, focused, framed, indirect or direct, in order to enhance specific areas of the monument in this case, as well as its ornamentation, columns, among others. The DIALux evo 11 programme has a system that registers the amount of luxes in the building, however, for the proposal, it will only focus on the exterior zone, which is the façade, Figure 10. The façade is considered to be a monument, since it does not require an exact amount of lighting, but rather a design that highlights certain areas or elements of the building, and with regard to the pavement, a minimum of 20 lux is required in accordance with the lighting standard.

Box 11

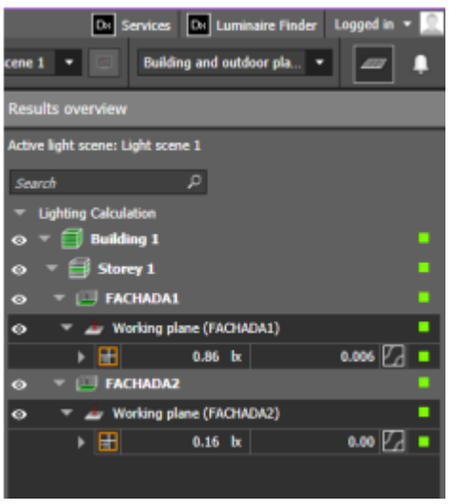


Figure 10

Results of the lux calculation on the façade

Own Elaboration

ISSN 2531-2162
RENIECYT-CONAHCYT: 1702902

Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan. Lighting design proposal for the facade of an historic art building. Journal of Architecture and Design. 8[19]-1-9: e60819109.
DOI: https://doi.org/10.35429/JAD.2024.8.19.6.1.9

5. Result

An analysis is made of the proposed solution to the lighting of El Cuartel Del arte to boost the city, enhancing the building through its illumination, resulting in a new perspective of the gallery, and creating a better view, enhancing the columns, the pediment and the main windows that are in the central façade. Figure 11 and 12 Rendering of the façade lighting design of El Cuartel del Arte.

Box 12

Figure 10

Rendering of the façade lighting design for El Cuartel del Arte *Own Elaboration*

Box 13

Figure 11

Lateral rendering of the façade lighting design of El Cuartel del Arte *Own Elaboration*

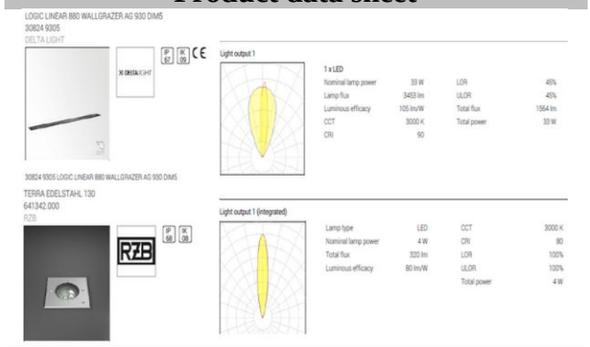
Luminaires used in the project: it is intended to use 2 types of luminaire for the lighting design of El Cuartel del Arte, 1 for the façade and 1 for the pavement, determining that they are suitable for the project. According to the description in Table 2 Description of the luminaires to be used and Table 3.

Box 14

Table 2

Images with description of the luminaire to be used in the project. Created with the DIALux programme

Product data sheet



Own Elaboration

Box 15

Table 2

Results DIALux evo11, façade luminaires. Developed with DIALux software

Luminaire list

Φ_{total}	P_{total}	Luminous efficacy
40781 lm	793.0 W	51.4 lm/W

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
21	Delta Light	30824 9305	LOGIC LINEAR 880 WALLGRAZER AG 930 DIM5	33.0 W	1561 lm	47.3 lm/W
25	RZB	641342.00 0	TERRA EDELSTAHL 130	4.0 W	320 lm	80.0 lm/W

Own Elaboration

Figures 12 and 13 show the 3D modelling of false colours in DUALux. The false colours work like a thermal camera, it tells you 100° red colour 50° orange colour, in blue colour 0, the false colours work similar but instead of telling you the level of heat they tell you the level of illumination, you can see the amount of luxes according to the lower bar in the following image and you can see how only some areas of the monument are highlighted and as in the access there is more light, the maximum required for the entrance is 20lux and you can see that it complies with what has been proposed.

ISSN 2531-2162
RENIECYT-CONAHCYT: 1702902

Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan. Lighting design proposal for the facade of an historic art building. Journal of Architecture and Design. 8[19]-1-9: e60819109.
DOI: https://doi.org/10.35429/JAD.2024.8.19.6.1.9

Box 16

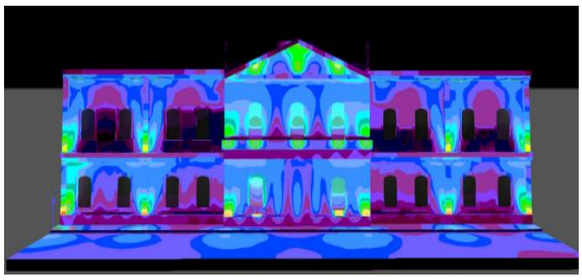


Figure 12

3D modelling of "El Cuartel del Arte", showing the false colours, made with the DIALux programme

Own Elaboration

Box 17

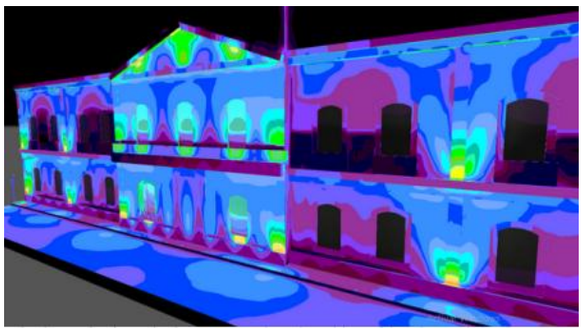


Figure 13

3D modelling side view of "El Cuartel del Arte", showing the false colours, produced with the DIALux programme

Own Elaboration

For the façade, the lighting that is functional and required is 20luxes minimum, for the preservation of the envelope, the lighting should not affect the material and its surroundings.

6. Conclusions

The lighting proposal presented seeks to highlight the architectural and cultural value of the historic monument, highlighting its most emblematic elements in a way that is harmonious and respectful of its surroundings. By employing a carefully planned lighting design that avoids invasive interventions and minimises light pollution, the conservation of the building and its proper integration into the urban landscape at night is guaranteed.

This approach not only promotes appreciation of the cultural heritage, but also enhances its tourist appeal, consolidating the monument as a symbol of identity and pride for the community.

The envelope of the historic monument plays an essential role in ensuring its protection from environmental conditions and preserving its architectural value. A well-planned lighting design not only enhances the conservation of the property, but also enhances its aesthetic appeal, integrating it harmoniously into the urban landscape at night.

The integration of energy-efficient LED luminaire technology was achieved and the spaces to be illuminated were optimised to showcase a historic building, highlighting its finishes and design.

References

[1] Casal Lopez-Valeiras. J. M. (1967). Artistic illumination of facades. Retrieved 04/07/2023. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiTpWWmPn_AhUQlWoFHcF3CbAQFnoECBYQAQ&url=https%3A%2F%2Finformesdelaconstruccion.revistas.csic.es%2Findex.php%2Finformesdelaconstruccion%2Farticle%2Fdownload%2F4073%2F4665&usg=AOvVaw3ocftcqPOt6tLD7gSwDFN0&opi=89978449

[2] DIAL GmbH (2023). DIALux is the software for your professional lighting design. Retrieved October 2023 from: https://www.dialux.com/es-ES/dialux

[3] E. Hernández (2023). Cuartel del Arte opens to young artists from Hidalgo. Retrieved October 2023 from: https://www.milenio.com/politica/comunidad/cuartel-del-arte-se-abrea-jovenes-hidalguenses

[4] E. Martín del Toro (2015). Spectacle architecture versus ARCHITECTURE. Retrieved October 2023 from: https://blog.deltoroantunez.com/2015/01/arquitectura-espectaculofrente.html

[5] INAH. 2012. Carta de Taxco, normativa para luminación de monumentos históricos. National Institute of Anthropology and History. https://iluminet.com/carta-de-taxco/

ISSN 2531-2162
RENIECYT-CONAHCYT: 1702902

Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan. Lighting design proposal for the facade of an historic art building. Journal of Architecture and Design. 8[19]-1-9: e60819109.
DOI: https://doi.org/10.35429/JAD.2024.8.19.6.1.9

[6] Giraldo-Castañeda, W., Guerrero-Torrenegra, A., & Ríos-Arce, A. F. D. L. (2024). Methodology for the valuation of built heritage: a view from the sun-building relationship. Case study: Universidad del Valle. Revista de Arquitectura (Bogotá), 26(2), 219-233.

ISSN 2531-2162
RENIECYT-CONAHCYT: 1702902

Zavala-Hernández, Karina, Ortega-Lazcano, Jesús Benjamín, Demesa-López, Francisco Noé and Serrano-Arellano, Juan. Lighting design proposal for the facade of an historic art building. Journal of Architecture and Design. 8[19]-1-9: e60819109.
DOI: https://doi.org/10.35429/JAD.2024.8.19.6.1.9

Article

[Title in TNRoman and Bold No. 14 in English and Spanish]

Surname, Name 1st Author*[a], Surname, Name 1st Co-author[b], Surname, Name 2nd Co-author[c] and Surname, Name 3rd Co-author[d] [No.12 TNRoman]

[a] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]
[b] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]
[c] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]
[d] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]

All ROR-Clarivate-ORCID and CONAHCYT profiles must be hyperlinked to your website.

Prot- University of South Australia • 7038-2013• 0000-0001-6442-4409 • 416112

CONAHCYT classification:
https://marvid.org/research_areas.php [No.10 TNRoman]
Area:
Field:
Discipline:
Subdiscipline:

DOI: https://doi.org/
Article History:
Received: [Use Only ECORFAN]
Accepted: [Use Only ECORFAN]
Contact e-mail address:
* ✉ [example@example.org]

Abstract [In English]

Must contain up to 150 words
Graphical abstract [In English]

Authors must provide an original image that clearly represents the article described in the article. Graphical abstracts should be submitted as a separate file. Please note that, as well as each article must be unique. File type: the file types are MS Office files.No additional text, outline or synopsis should be included. Any text or captions must be part of the image file. Do not use unnecessary white space or a "graphic abstract" header within the image file.

Keywords [In English]
Indicate 3 keywords in TNRoman and Bold No. 10

Abstract [In Spanish]

Must contain up to 150 words
Graphical abstract [In Spanish]

Authors must provide an original image that clearly represents the article described in the article. Graphical abstracts should be submitted as a separate file. Please note that, as well as each article must be unique. File type: the file types are MS Office files.No additional text, outline or synopsis should be included. Any text or captions must be part of the image file. Do not use unnecessary white space or a "graphic abstract" header within the image file.

Keywords [In Spanish]
Indicate 3 keywords in TNRoman and Bold No. 10

Citation: Surname, Name 1st Author, Surname, Name 1st Co-author, Surname, Name 2nd Co-author and Surname, Name 3rd Co-author. Article Title. ECORFAN Journal-Mexico. Year. V-N: Pages [TN Roman No.10].

Introduction

Text in TNRoman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features.

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

[Title No.12 in TNRoman, single spaced and bold]

Products in development No.12 TNRoman, single spaced.

Including figures and tables-Editable

In the article content any table and figure should be editable formats that can change size, type and number of letter, for the purposes of edition, these must be high quality, not pixelated and should be noticeable even reducing image scale.

[Indicating the title at the bottom with No.10 and Times New Roman Bold]

Box

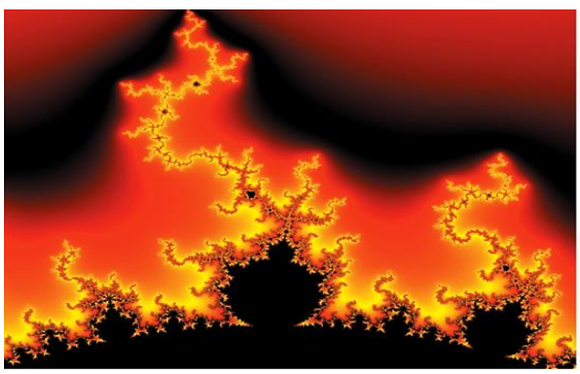


Figure 1

Title [Should not be images-everything must be editable]

Source [in italic]

Box

Table 1

Title [Should not be images-everything must be editable]

Source [in italic]

The maximum number of Boxes is 10 items

For the use of equations, noted as follows:

$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \qquad [1]$$

Must be editable and number aligned on the right side.

Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The results shall be by section of the article.

Conclusions

Clearly explain the results and possibilities of improvement.

Annexes

Tables and adequate sources.

The international standard is 7 pages minimum and 14 pages maximum.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

ISSN-On line: 2531-2162

Author contribution

Specify the contribution of each researcher in each of the points developed in this research.

Prot-
Benoit-Pauleter, Gerard: Contributed to the project idea, research method and technique.

Availability of data and materials

Indicate the availability of the data obtained in this research.

Funding

Indicate if the research received some financing.

Acknowledgements

Indicate if they were financed by any institution, University or company.

Abbreviations

List abbreviations in alphabetical order.

Prot-

ANN	Artificial Neural Network

References

Use APA system. Should not be numbered, nor with bullets, however if necessary numbering will be because reference or mention is made somewhere in the Article.

Use the Roman alphabet, all references you have used should be in Roman alphabet, even if you have cited an article, book in any of the official languages of the United Nations [English, French, German, Chinese, Russian, Portuguese, Italian, Spanish, Arabic], you should write the reference in Roman alphabet and not in any of the official languages.

Citations are classified the following categories:

Antecedents. The citation is due to previously published research and orients the citing document within a particular scholarly area.

Basics. The citation is intended to report data sets, methods, concepts and ideas on which the authors of the citing document base their work.

Supports. The citing article reports similar results. It may also refer to similarities in methodology or, in some cases, to the reproduction of results.

Differences. The citing document reports by means of a citation that it has obtained different results to those obtained in the cited document. This may also refer to differences in methodology or differences in sample sizes that affect the results.

Discussions. The citing article cites another study because it is providing a more detailed discussion of the subject matter.

The URL of the resource is activated in the DOI or in the title of the resource.

Prot-

Mandelbrot, B. B. [2020]. Negative dimensions and Hölders, multifractals and their Hölder spectra, and the role of lateral preasymptotics in science. Journal of Fourier Analysis and Applications Special. 409-432.

Intellectual Property Requirements for editing:

- Authentic Signature in Color of Originality Format Author and Coauthors.
- Authentic Signature in Color of the Acceptance Format of Author and Coauthors.
- Authentic Signature in blue color of the Conflict of Interest Format of Author and Co-authors.

Reservation to Editorial Policy

Journal Architecture and Design reserves the right to make editorial changes required to adapt the Articles to the Editorial Policy of the Journal. Once the Article is accepted in its final version, the Journal will send the author the proofs for review. ECORFAN® will only accept the correction of errata and errors or omissions arising from the editing process of the Journal, reserving in full the copyrights and content dissemination. No deletions, substitutions or additions that alter the formation of the Article will be accepted.

Code of Ethics - Good Practices and Declaration of Solution to Editorial Conflicts

Declaration of Originality and unpublished character of the Article, of Authors, on the obtaining of data and interpretation of results, Acknowledgments, Conflict of interests, Assignment of rights and Distribution

The ECORFAN-Mexico, S.C Management claims to Authors of Articles that its content must be original, unpublished and of Scientific, Technological and Innovation content to be submitted for evaluation.

The Authors signing the Article must be the same that have contributed to its conception, realization and development, as well as obtaining the data, interpreting the results, drafting and reviewing it. The Corresponding Author of the proposed Article will request the form that follows.

Article title:

– The sending of an Article to Journal Architecture and Design emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Format of Originality for its Article, unless it is rejected by the Arbitration Committee, it may be withdrawn.

– None of the data presented in this article has been plagiarized or invented. The original data are clearly distinguished from those already published. And it is known of the test in PLAGSCAN if a level of plagiarism is detected Positive will not proceed to arbitrate.

– References are cited on which the information contained in the Article is based, as well as theories and data from other previously published Articles.

– The authors sign the Format of Authorization for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Spain considers pertinent for disclosure and diffusion of its Article its Rights of Work.

– Consent has been obtained from those who have contributed unpublished data obtained through verbal or written communication, and such communication and Authorship are adequately identified.

– The Author and Co-Authors who sign this work have participated in its planning, design and execution, as well as in the interpretation of the results. They also critically reviewed the paper, approved its final version and agreed with its publication.

– No signature responsible for the work has been omitted and the criteria of Scientific Authorization are satisfied.

– The results of this Article have been interpreted objectively. Any results contrary to the point of view of those who sign are exposed and discussed in the Article.

Copyright and Access

The publication of this Article supposes the transfer of the copyright to ECORFAN-Mexico, SC in its Holding Spain for its Journal Architecture and Design, which reserves the right to distribute on the Web the published version of the Article and the making available of the Article in This format supposes for its Authors the fulfilment of what is established in the Law of Science and Technology of the United Mexican States, regarding the obligation to allow access to the results of Scientific Research.

Article Title:

Name and Surnames of the Contact Author and the Coauthors	Signature
1.	
2.	
3.	
4.	

Principles of Ethics and Declaration of Solution to Editorial Conflicts

Editor Responsibilities

The Publisher undertakes to guarantee the confidentiality of the evaluation process, it may not disclose to the Arbitrators the identity of the Authors, nor may it reveal the identity of the Arbitrators at any time.

The Editor assumes the responsibility to properly inform the Author of the stage of the editorial process in which the text is sent, as well as the resolutions of Double-Blind Review.

The Editor should evaluate manuscripts and their intellectual content without distinction of race, gender, sexual orientation, religious beliefs, ethnicity, nationality, or the political philosophy of the Authors.

The Editor and his editing team of ECORFAN® Holdings will not disclose any information about Articles submitted to anyone other than the corresponding Author.

The Editor should make fair and impartial decisions and ensure a fair Double-Blind Review.

Responsibilities of the Editorial Board

The description of the peer review processes is made known by the Editorial Board in order that the Authors know what the evaluation criteria are and will always be willing to justify any controversy in the evaluation process. In case of Plagiarism Detection to the Article the Committee notifies the Authors for Violation to the Right of Scientific, Technological and Innovation Authorization.

Responsibilities of the Arbitration Committee

The Arbitrators undertake to notify about any unethical conduct by the Authors and to indicate all the information that may be reason to reject the publication of the Articles. In addition, they must undertake to keep confidential information related to the Articles they evaluate.

Any manuscript received for your arbitration must be treated as confidential, should not be displayed or discussed with other experts, except with the permission of the Editor.

The Arbitrators must be conducted objectively, any personal criticism of the Author is inappropriate.

The Arbitrators must express their points of view with clarity and with valid arguments that contribute to the Scientific, Technological and Innovation of the Author.

The Arbitrators should not evaluate manuscripts in which they have conflicts of interest and have been notified to the Editor before submitting the Article for Double-Blind Review.

Responsibilities of the Authors

Authors must guarantee that their articles are the product of their original work and that the data has been obtained ethically.

Authors must ensure that they have not been previously published or that they are not considered in another serial publication.

Authors must strictly follow the rules for the publication of Defined Articles by the Editorial Board.

The authors have requested that the text in all its forms be an unethical editorial behavior and is unacceptable, consequently, any manuscript that incurs in plagiarism is eliminated and not considered for publication.

Authors should cite publications that have been influential in the nature of the Article submitted to arbitration.

Information services

Indexation - Bases and Repositories

LATINDEX (Scientific Journals of Latin America, Spain and Portugal)
EBSCO (Research Database - EBSCO Industries)
RESEARCH GATE (Germany)
GOOGLE SCHOLAR (Citation Indexes-Google)
MENDELEY (Bibliographic References Manager)
REDIB (Ibero-American Network of Innovation and Scientific Knowledge- CSIC)
HISPANA (Bibliographic Information and Guidance-Spain)

Publishing Services:

Citation and Index Identification H
Management of Originality Format and Authorization
Testing Article with PLAGSCAN
Article Evaluation
Certificate of Double-Blind Review
Article Edition
Web layout
Indexing and Repository
ArticleTranslation
Article Publication
Certificate of Article
Service Billing

Editorial Policy and Management

38 Matacerquillas, CP-28411. Moralzarzal –Madrid-España. Tel: +52 1 55 6159 2296, +52 1 55 1260 0355, +52 1 55 6034 9181; Correo electrónico: contact@ecorfan.org www.ecorfan.org

Management Offices

38 Matacerquillas, CP-28411. Moralzarzal –Madrid-España. Phones: +52 1 55 6159 2296, +52 1 55 1260 0355, +52 1 55 6034 9181; Email: contact@ecorfan.org www.ecorfan.org.

Journal of Architecture and Design

2531 2162
ISSN 2531 - 2162

www.ecorfan.org