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Investing in the Future of Education: Conservation Plan for Public Schools through Degradation and Performance Models

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Abstract:
Public schools play a crucial role in building an educated, inclusive, and egalitarian society, serving as pillars for educational and social development. Investing in these institutions not only shapes the future of the local community but also plays a crucial role in advancing the country as a whole. Given this significance, it is imperative that the built environment complies with regulatory standards, meeting the needs of students. This article proposes to assist in the Post-Occupancy Evaluation (POE) system through technical inspections conducted in six public schools in the Federal District. Utilizing the Ross-Heidecke Depreciation Methodology and the Gravity, Urgency, Tendency (GUT) assessment, the research aims to identify positive and negative aspects in the built spaces and suggest alternatives for immediate interventions, contributing to improvements in current and future projects. By maintaining well-preserved environments, periodic maintenance not only ensures adequate infrastructure but also creates ideal conditions for educational development, positively impacting the well-being and safety of students and education professionals. The integrated approach focuses on the effectiveness and sustainability of educational environments, aiming to create conducive spaces for quality learning.

Key words: School Conservation, Building Inspections, Degradation and Performance Models.

1. Introduction

As public schools play an essential role in the educational and social development of the country. Investing in these institutions is crucial for shaping the future of local communities and contributing to national progress. The need for an appropriate built environment in schools stands out as crucial to enable students to occupy educational spaces effectively, promoting a conducive environment for learning and the holistic development of students. Ensuring the quality and suitability of the built environment in public schools is essential to foster education and the well-being of Brazilian society.

In the meantime, the routine evaluation of these schools plays a crucial role in the current scenario, as deficiencies often arise due to a lack of maintenance, potentially causing significant damage or affecting other structures when not adequately supervised by experts. Various methodologies and regulations guide this process, allowing for a precise assessment of identified parameters.

One widely used evaluation methodology is the Gravity, Urgency, Tendency (GUT) method by Kepner & Tregoe, developed for prioritizing in strategic diagnosis, also applied to identify the organization's strategic posture.

Another method of great importance is the Ross-Heidecke depreciation method, which allows for a thorough analysis of the state of conservation, using variables proposed by Heidecke. These variables encompass various systems, such as roofing, sealing, weight, facilities, structure, accessibility, fire-fighting systems, etc. The application of this method enhances the understanding of the condition of each element, providing a comprehensive view of the built environment and contributing to the identification of areas that require specific interventions or improvements.

In the context of evaluations, this work aims to contribute to the improvement of the Post-Occupancy Evaluation (POE) Interactive System, seeking to present more suitable design solutions. This continuous research process encompasses both the functional and formal perspectives of architecture and urbanism, aiming to provide valuable insights for the development of more efficient spaces.

In this context, the present work includes inspections in six public schools in the Federal District, in the following administrative regions: Candangolândia, Ceilândia, Núcleo Bandeirante, Sobradinho, Taguatinga, and the Plano Piloto, where a database will be created to assess the correlation between the applied methodologies and evaluated systems (e.g., roofing, enclosures, flooring, and facilities) to identify the positive and negative aspects in the infrastructure systems, offering managers and designers alternatives for strategic interventions throughout the building's use.

2. Theoretical Reference

2.1 School Infrastructure and Investments

A school infrastructure, understood as "the facilities, equipment, and services necessary to ensure the school's operation and assist in student learning" (GARCIA, 2014), has been a highlighted aspect in Brazilian education.

Studies, such as that of Castro and Fletcher (1986), which analyzed the material conditions of Brazilian schools, emphasize the importance of infrastructure in the efficiency and effectiveness of public spending on education.

E. Xavier et al. (2023) highlighted that, in recent years, there has been an increase in awareness regarding the importance of improving the educational system. Governments take on the responsibility of directing substantial financial resources to ensure that educational institutions have the proper infrastructure, qualified teachers, and appropriate materials.

In this context, the strategic application of methods to assess the state of conservation of school infrastructure can result in the effective optimization of public resources. This approach aims to ensure that investments translate into tangible improvements, promoting efficiency in resource management and contributing to an educational environment more conducive to quality learning.

2.2 Public schools in the Federal District

The public education network of the Federal District (DF) is facing significant demand, encompassing students from early childhood education, elementary school, and high school. The current scenario includes 811 public schools, with 19 new units under construction and two undergoing renovations, while another two are in the process of complete reconstruction (Agência Brasília, 2022).

Given this expansion, the implementation of regular maintenance in the constructed spaces becomes crucial to provide a safe, healthy, and conducive learning environment. These regular practices not only identify and address potential structural, electrical, and plumbing issues but also contribute to the preservation of public assets, extending the lifespan of buildings and avoiding excessive costs associated with emergency renovations. Thus, by maintaining well-preserved environments, periodic maintenance fosters optimal conditions for educational development, positively impacting the well-being and safety of students and education professionals.

According to the Department of Education (Educação, 2023), approximately R$ 100 million were invested in public schools in the DF in the first semester for the acquisition of equipment or works in various schools within the education network.

2.3 Post-Occupancy Evaluation (POE)

According to ONO, R., ORNSTEIN, ET. AL (2018), post-occupancy evaluation (POE) consists of a multimethod approach for assessing performance throughout use. Its main advantages lie in considering the viewpoints of experts and, especially, meeting the objective and subjective needs of users during the use of the built environment.

The objective is to provide a foundation for and plan interventions in construction, as well as monitor building performance based on lived experiences. This involves considering technical, functional, behavioral, and cultural factors. In this regard, the application of POE during the use of a building becomes a very useful resource as it presupposes the verification of compliance with performance requirements and criteria, observation of relevant technical standards, identification of critical aspects, and the proposition of actions to address these issues, always with a view to user satisfaction (ONO, R., ORNSTEIN, ET. AL., 2018).

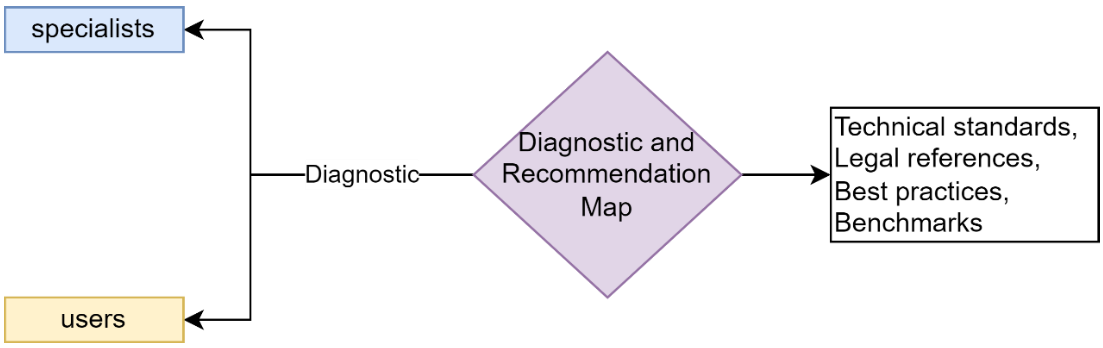

Figure 1 - Diagram of Post-Occupancy Evaluation application.

2.4 Gravity, Urgency, Tendency (GUT)

A GUT methodology assesses each factor according to the criteria of severity, urgency, and trend. According to OLIVEIRA (1999), despite GUT methodology being developed for setting priorities in strategic diagnosis, it can also be applied to identify the organization's strategic posture.

In light of the above, this methodology can be used to establish the internal predominance of strengths or weaknesses and external predominance concerning opportunities or threats, factors that characterize the organizational strategic posture.

The GUT approach involves classifying occurrences based on three aspects:

- G - gravity: evaluating the intensity or depth of the damage that can occur if not addressed;
- U - urgency: assessing the time needed or available to correct the identified problems;
- T - tendency: evaluating the evolutionary behavior (whether it will improve or worsen) in the absence of action.

For the method's application, it is necessary to list the points of analysis, anomalies or faults, score each topic, classify the problems, and, finally, make decisions.

Considering the performance standard NBR 15575 (ABNT, 2013), which is defined by three pillars: safety, habitability, and sustainability. The concepts used for determining the GUT values took into account the service life (VU), structural and user safety, and functionality. Functionality is one of the habitability requirements.

In Brazil (GOMIDE; NETO; GULLO, 2011), recognized studies on the GUT table were adapted for the analysis of perceptible damages during sensory inspection. The author suggests calibrating the weights assigned to severity, urgency, and trend as per Table 1.

Table 1 - GUT Table developed by KEPNER and TREGOE

Degree	gravity	urgency	Tendency	weight
Total	Loss of human lives, environmental damage, or building collapse	Ongoing event	Immediate evolution	10
High	Injuries to people, harm to the environment, or damage to the building	Event about to occur	Short-term evolution	8
Medium	Discomfort, environmental or building deterioration	Event predicted in the near future	Medium-term evolution	6
Low	Minor inconveniences or small financial losses	Event predicted in the distant future	Long-term evolution	3
None	None	Unexpected event	Will not evolve	1

2.5 Método de depreciação de Ross-Heidecke

According to Pimenta (2011), Ross's methodology consists of the average of linear and exponential depreciation models as follows:

- Linear Model: Involving only two variables to determine the depreciation of an asset through the depreciation factor (k). This factor is determined by the variables of the current age and the number of years of the asset's useful life, according to the following equation:

$$k = \frac{u}{n} \quad (1)$$

k: Accumulated depreciation factor;
u: Current age of the property;
n: Number of years of the property's useful life.

According to the same author (PIMENTA, 2011), the use of this depreciation model is valid in some cases, but concerning the real estate market, it does not prove to be an effective tool for depreciation calculation, incapable of providing results consistent with reality.

- Exponential Model: It consists of the quadratic depreciation model based on linear depreciation methodology, aiming to obtain more accurate results. Thus, the following equation is considered:Ainda de acordo com o mesmo autor (PIMENTA, 2011), a utilização deste modelo de depreciação é válida em alguns casos, mas no que diz respeito ao mercado imobiliário, não se apresenta como ferramenta eficaz para o cálculo de depreciação, sendo incapaz de fornecer resultados coerentes com a realidade.

$$k = \left(\frac{u}{n}\right)^2 \qquad (2)$$

Having said that, Ross's methodology combines the two depreciation models presented, where the depreciation factor (k) is the average of these models. Once again, with the aim of reducing errors and getting closer to reality. The following equation represents the mentioned mathematical model:

$$k = \frac{1}{2} * \left[\frac{u}{n} + \left(\frac{u}{n}\right)^2\right] \qquad (3)$$

k: Accumulated depreciation factor;
u: Current age of the property;
n: Number of years of the property's useful life.

Graphically, the behavior of the models can be compared, as shown in Figure 2. Additionally, we can observe that Ross's model is based on the average of the models (i.e., linear, exponential).

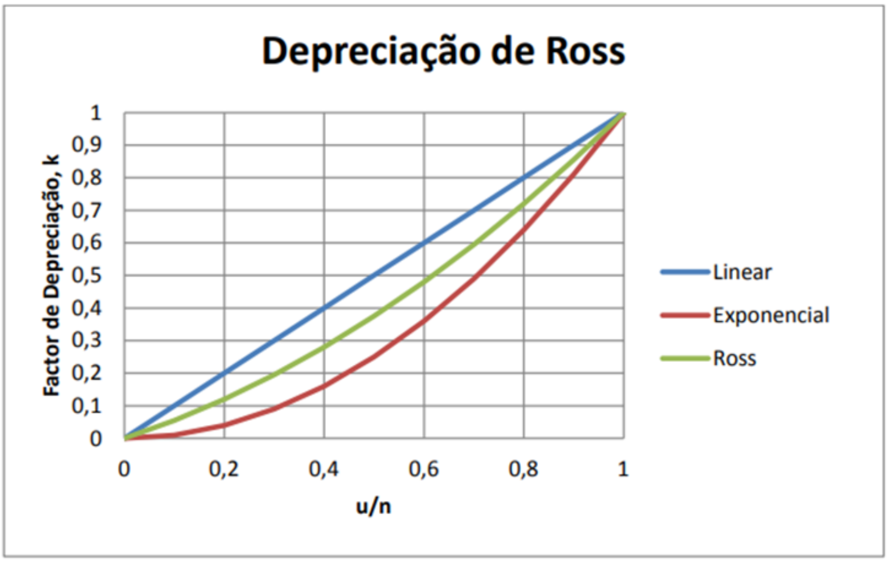

Figure 2 - Comparison between depreciation models

On the other hand, Heidecke's method consists of determining the conservation state (C) through five main categories and four intermediate ones, as presented in Table 2.

Table 2 - Heidecke method

Category	Conservation State	C
a	New	0,000
b	Between new and regular	0,003
c	Regular	0,025
d	Between regular and in need of minor repairs	0,081
e	In need of minor repairs	0,181
f	In need of minor to major repairs	0,332
g	In need of major repairs	0,526
h	In need of major repairs to the building	0,752
i	Valueless	1,000

According to Oliveira, I. P. (2019), the state of conservation (C) qualitatively assesses the maintenance of the property and has a corresponding quantitative aspect. The values are fixed and widely used in the real estate appraisal market.

In an effort to reduce subjectivity in qualifying the state of conservation, Pereira (2013) introduces Table 3, providing examples of reference characteristics for each conservation state (C) according to Heidecke.

Table 3 - Conservation State (C)

Category	Conservation State
New	New building or with a comprehensive and substantial renovation, less than two years old, showing only signs of natural wear on the external paint.
Between new and regular	New building or with a comprehensive and substantial renovation, less than two years old, needing only a light coat of paint to restore its appearance.
Regular	Semi-new building or with a comprehensive and substantial renovation, between 2 and 5 years old, whose overall condition can be restored with occasional repairs, with localized superficial cracks and/or external and internal painting of the building.
Between regular and minor repairs	Semi-new building or with a comprehensive and substantial renovation, between 2 and 5 years old, whose overall condition can be restored with repair of localized superficial cracks and external and internal painting.
Minor repairs	Building whose overall condition can be restored with internal and external painting, after repairing widespread superficial cracks, without recovering the structural system. Eventually, there may be a need to review the hydraulic and electrical systems.
Between minor repairs and major repairs	Building whose overall condition can be restored with internal and external painting. After repairing cracks, stabilization and/or localized recovery of the structural system are expected. Hydraulic and electrical installations can be restored through review and/or occasional replacement of some naturally worn-out parts. Occasionally, replacement of floor and wall coverings in one or another compartment may be necessary. Review of waterproofing or replacement of roof tiles may be required.
Between major repairs and no value	Building whose overall condition can be restored with stabilization and/or recovery of the structural system, replacement of masonry regularization, crack repairs, replacement of hydraulic and electrical installations, replacement of floor and wall coverings, replacement of waterproofing or roof.
No value	Building in a state of ruin.

Finally, the combined Ross-Heidecke method involves depreciation (k), which varies nonlinearly (Ross) based on the property's condition (Heidecke), as presented in Table 1. Mathematically, the methodology is expressed as follows:

$$k = \frac{1}{2} * \left[\frac{u}{n} + \left(\frac{u}{n}\right)^2\right] + \left[1 - \frac{1}{2} * \left[\frac{u}{n} + \left(\frac{u}{n}\right)^2\right]\right] * C \quad (4)$$

k: Accumulated depreciation factor;
u: Current age of the property;
n: Number of years of useful life of the property;
C: State of conservation.

3. Technical Inspections in Schools

The inspections conducted in public schools in the Federal District were predominantly visual, aimed at identifying anomalies and apparent faults, occasionally utilizing equipment and/or inspection devices. In accordance with technical standards (i.e., NBR-16474:2020, NBR-5674:2012, NBR 14037:1998), the following procedures were adopted:

a) Determination of the main characteristics of the building;
b) Anamnesis regarding the conservation, maintenance, and operation of the building;
c) Checklist;
d) Inspection of construction components, technical, functional, and conservation assessment;
e) System inspections;
f) General and detailed photographs;
g) Gathering of information;
h) Indication of technical guidelines and priority order for maintenance.

In addition to the procedures, each subsystem was assessed in two distinct yet complementary ways. The first pertains to the degradation state based on the Severity, Urgency, Trend (GUT) criteria by Kepner & Tregoe. The second involves the conservation state, following Heidecke's variable.

Separately or together, these variables can indicate changes in the final lifespan of the building and contribute to the emergence of pathological manifestations. At the end of each analyzed system, technical indicators will be qualified with the following arrangement of information.

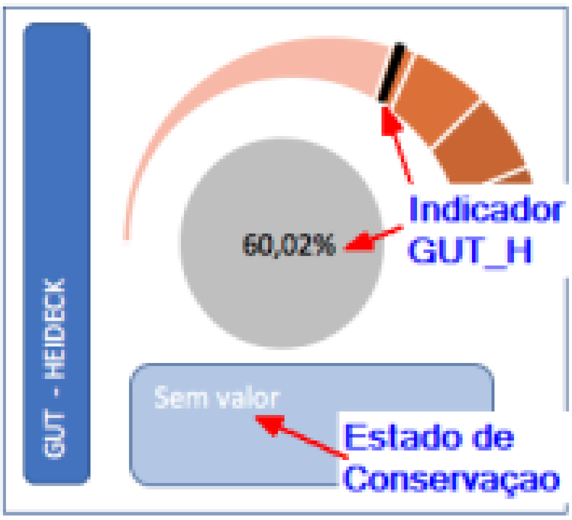

Figure 3 - GUT - Heidecke Indicator

Therefore, each system was assessed in relation to each of the two methods, being able to receive values from 0.0% to 100.0% according to the degradation and conservation criteria. Within the scope of the systems, the inspections were divided into nine main systems, namely: Roofing, enclosures, flooring, electrical installations, plumbing installations, structure, accessibility, landscaping, and fire protection.

The following topics detail each of these systems evaluated in the context of inspections in schools in the Federal District.

3.1 Roofing

The roofing system plays crucial roles, including ensuring watertightness against rainwater, promoting healthiness, and providing protection against natural agents. Components such as the support structure (rafters, beams, purlins, and ridges) and the subsystem of gutters, flashings, and rainwater collectors are essential. Tiles, made of various materials, collect and direct water to the gutters. The lightning protection system (SPDA), although electrical, is visually associated with the roofing. Reservoirs and expansion joints related to the roofing are assessed for waterproofing and localized maintenance.

3.2 Enclosures

The enclosure system comprises crucial elements in construction, such as facades, walls, and internal partitions, playing a vital role in the comfort and safety of the built environment. For a comprehensive assessment, it is essential to consider various elements, such as the quality and conservation of paint, the integrity of masonry and vertical sealing, the condition of metal frames, including the presence of glass and security grilles. Additionally, the evaluation should address the state of ceramic coatings, the presence of water percolation in masonry, and the type and condition of the ceiling used in construction.

3.3 Flooring

The flooring system covers both internal and external areas. For a thorough and effective assessment, various elements need to be considered. In the case of internal flooring, it is essential to analyze the quality and integrity of the coating, identifying possible damage, wear, or irregularities. For external flooring, it is crucial to evaluate its resistance to weather conditions, ensuring durability and safety.

3.4 Electrical Installations

The inspection of the electrical installations system involves examining the condition and suitability of the electrical wiring, identifying possible wear or damage over time. Protective devices, such as circuit breakers and fuses, must be checked to ensure their proper functioning in overload situations. The existence of grounding and compliance with electrical safety standards are fundamental aspects to consider.

3.5 Plumbing Installations

The inspection of the plumbing installations system requires a careful analysis of the integrity and watertightness of the pipes to identify any signs of leaks. Elements such as valves, valves, and connections need inspection to assess their functionality and detect any signs of wear. The evaluation of water pressure and the sewage system is also necessary for the early identification of potential problems.

3.6 Structure

The evaluation of the structural system requires an analysis of key elements such as slabs, beams, and columns. It is essential to verify the integrity, stability, and possible signs of wear or deterioration in these structural components. The inspection aims to identify cracks, fissures, corrosion, or any other anomalies that could compromise the safety and durability of these structures.

3.7 Accessibility

Assessing the accessibility system during an inspection requires an analysis of elements that ensure the inclusion and safety of users. It is fundamental to check the compliance of ramps, handrails, and elevators with specific accessibility standards. Additionally, the inspection should include the analysis of doors, tactile signage, tactile floors, and adapted bathrooms, ensuring that the environment is fully accessible for people with different needs.

3.7 Landscaping

The assessment of the landscaping system contributes to the aesthetics and functionality of outdoor areas. It is important to verify the conservation status and vitality of plants, as well as the efficiency of irrigation systems. Decorative elements such as sculptures or urban furniture should be inspected for integrity and safety. Furthermore, the analysis includes checking the overall condition of the soil, preventing erosion or water accumulation issues.

3.7 Fire Protection

The assessment of the fire protection system involves analyzing elements designed to prevent and control fires. Among the main components to be evaluated are fire extinguishers, which should be strategically located and in good condition, with clear signage indicating their location. Automatic systems, such as sprinklers, require verification of proper functioning. Emergency exits, stairs, and handrails must be inspected to ensure effectiveness in evacuations during a fire. The presence and functionality of fire alarms and emergency lighting are also crucial elements to consider in the assessment, aiming to ensure the safety of the building occupants in emergency situations.

4. Analysis

The study in question encompasses the analysis of six schools currently in use within the Federal District. These are:

- EC_AN407: Escola Classe 407 Norte;
- EC_CDEC01: Escola Classe 01 da Candangolândia;
- CEF_CEI026: Centro de Ensino Fundamental 26 da Ceilândia;
- CEF_CEI027: Centro de Ensino Fundamental 27 da Ceilândia;
- CEM_NB00JK: Centro de Ensino Médio Julia Kubitschek;
- CAIC_SOB II: Caic Júlia Kubitschek De Oliveira;

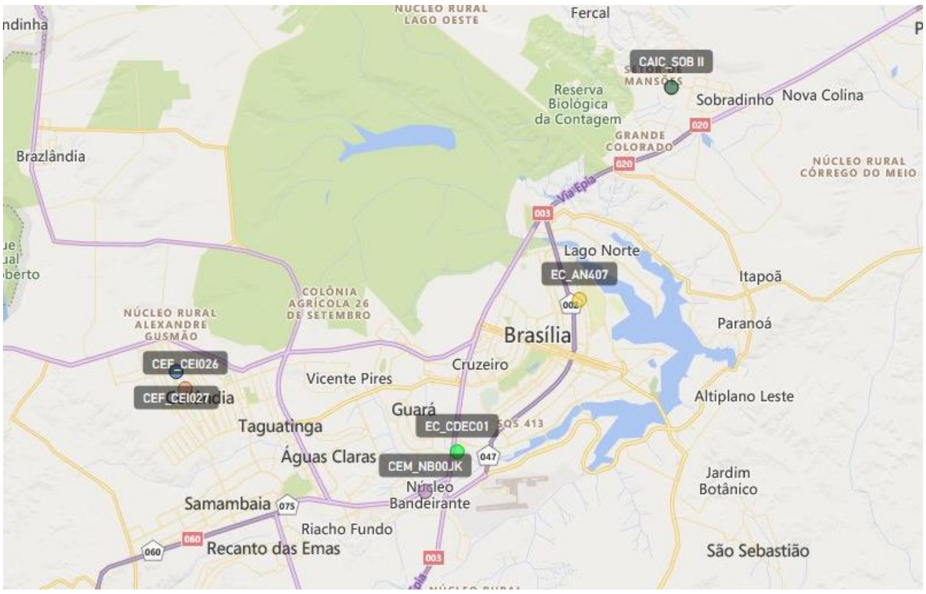

Figure 4 - School Locations

The methodology was developed in three stages (i.e., mapping of systems, database conception, analysis of reports).

The unification and compatibility of systems involve handling the systems outlined in the technical reports, that is, consolidating the description and understanding of the modules presented in the previous section (e.g., roofing, enclosures, flooring, installations, structure, accessibility, landscaping, and fire protection), as illustrated in Figure 5

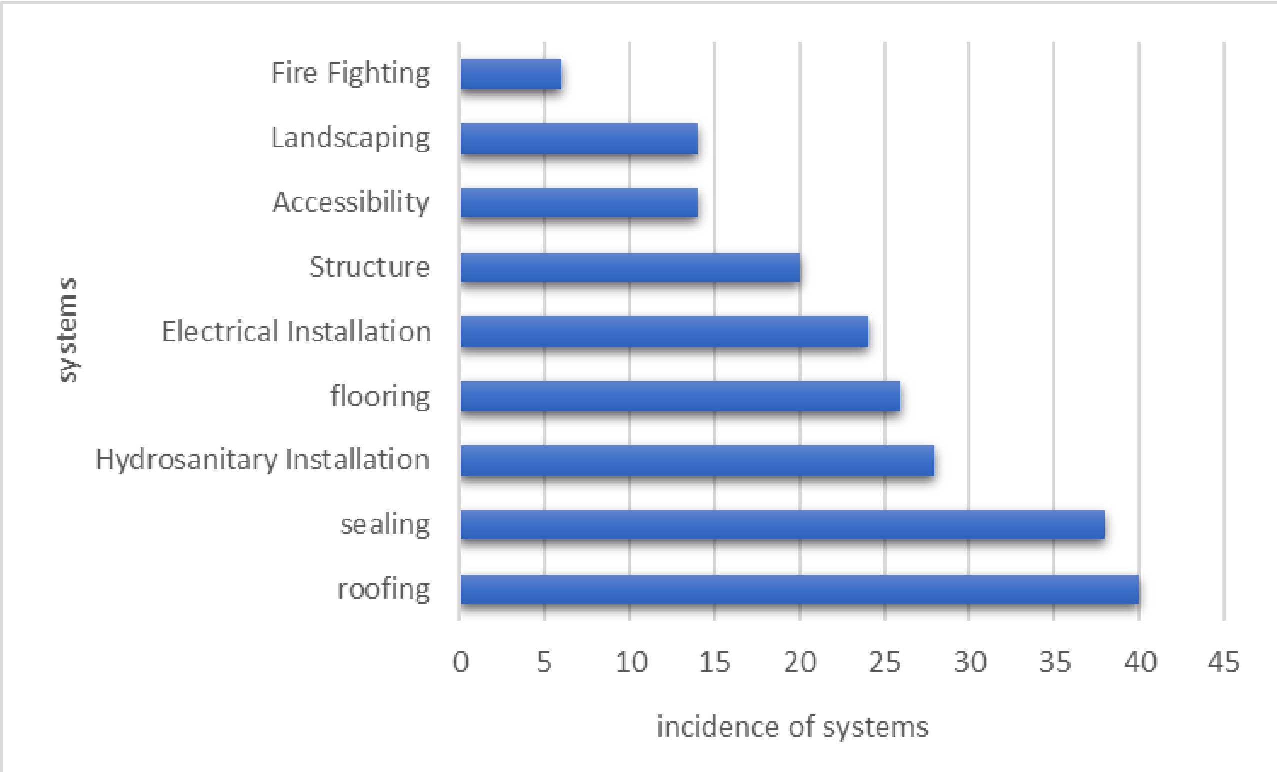

Figure 5 - Mapped systems

The conception of the database involves the need for logic among the data presented in the technical reports. According to TOREY et al (2007), a Database is a more complex object; it is a collection of stored and interrelated data that serves the needs of various users within one or more organizations, meaning interconnected collections of many different types of tables.

After the stages of unification and database conception, it becomes possible to analyze the application of the presented methodologies (i.e., GUT and Ross-Heidecke depreciation) within the context of the six analyzed schools.

In a general context, by implementing all the mentioned systems in each of the six schools, a comprehensive result was obtained to facilitate visualization in the application of the GUT methodology, as previously presented in Table 1.

Thus, the study revealed consistency in behavior among the schools, with severity classified as low to medium, urgency predominantly low, and trend ranging from low to medium. Figure 6 illustrates this pattern through the color scale presented.

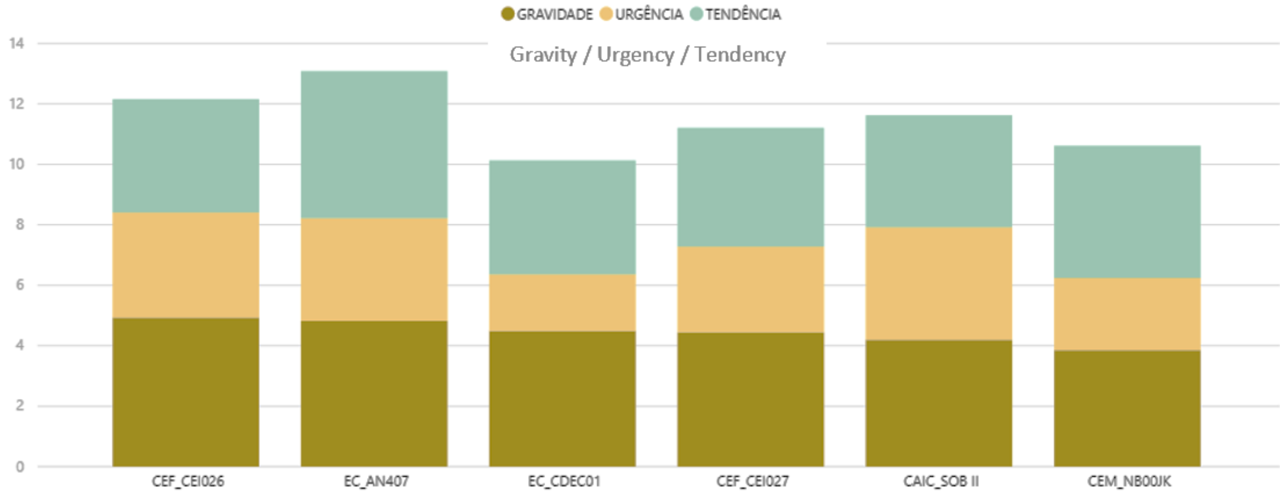

Figure 6 - Analysis of GUT methodology

Within the Ross-Heidecke methodology, according to the collected data, all six educational institutions examined fall within a range from grade D, indicating a moderately preserved state requiring minimal interventions, to grade F, signaling a condition that demands repairs ranging from minor to more extensive and critical interventions, as detailed in Figure 7.

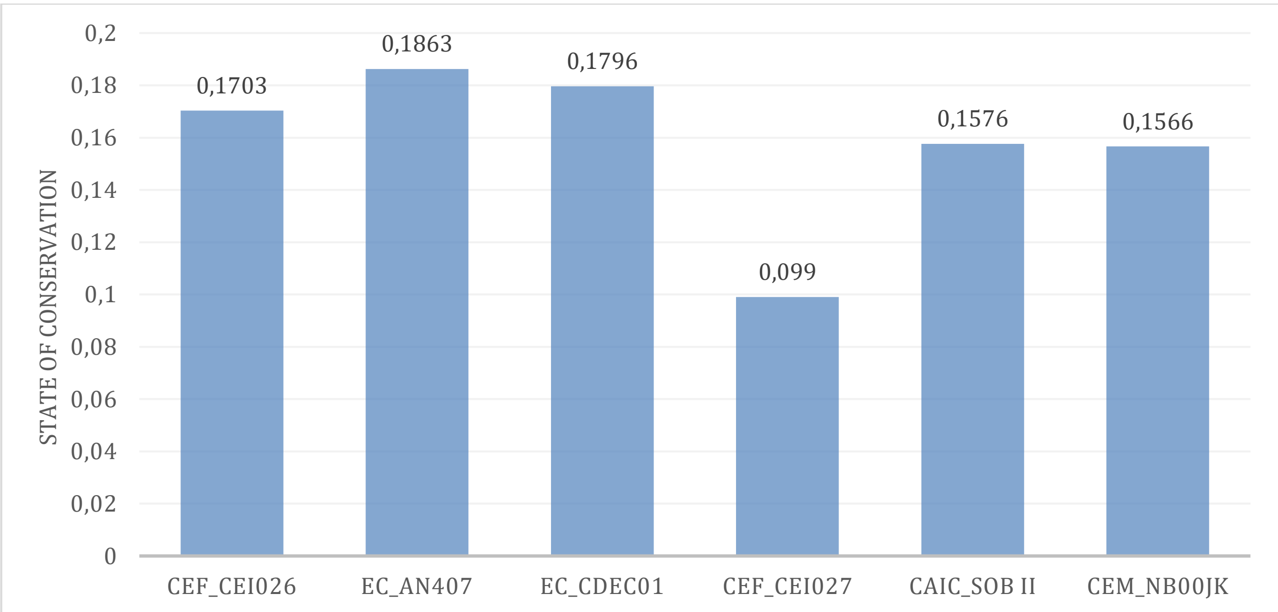

Figure 7 - Analysis using the Ross-Heidecke methodology

Analyzing the systems together, it was observed that the methodologies present classifications indicating the need for maintenance, showing a similar degree of intervention, even though each within its evaluation criterion.

Furthermore, an individual assessment of the systems was conducted to identify those with higher criticality and verify if there was a similar pattern among the six schools. Figure 8 illustrates the evaluation of the electrical system.

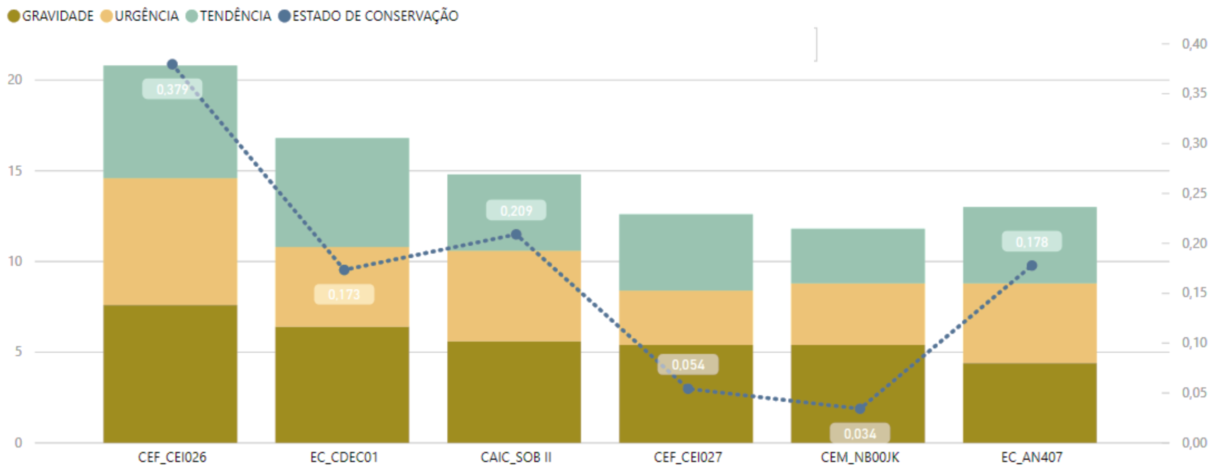

Figure 8 – Exemplo de análise do Sistema elétrico

In general, it was possible to observe the absence and/or lack of maintenance in the fire protection system, and the most critical issues were identified in the electrical and plumbing systems. Additionally, it was noted that accessibility, for the most part, does not meet the requirements established by the Brazilian Standard ABNT NBR 9050/2020, indicating the need for updates in this aspect.

In the context of absence and/or lack of maintenance in the fire protection system, there is a critical risk as it directly compromises the safety of occupants in emergency situations, potentially resulting in significant physical and material damage. Additionally, deficiencies in electrical and hydraulic installation systems indicate potential threats to the structural integrity of the environment, increasing the likelihood of operational failures, short circuits, or leaks, which, in turn, can lead to accidents and damage to property and its users.

The finding that accessibility does not meet the requirements established by the Brazilian Standard ABNT NBR 9050/2020 represents another risk for users. Non-compliance in this aspect can result in obstacles and limitations in the access of people with reduced mobility, compromising inclusion and equality in the school environment. This not only jeopardizes the safety of these individuals but can also lead to legal implications and ethical issues related to accessibility and equal opportunities.

Therefore, it becomes imperative not only to identify but also to proactively address the diagnosed problems by implementing preventive and corrective measures. This approach not only contributes to mitigating risks associated with safety, structural integrity, and accessibility in the school environment but also emphasizes the importance of actively participating in the Post-Occupancy Evaluation (POE) system. By aligning corrective actions with the results of this continuous analysis, we not only address immediate needs but also establish a constant cycle of improvement in the quality of the built environment. This integration of POE into the correction process not only ensures effective solutions but also promotes a culture of continuous improvement, prioritizing safety, integrity, and accessibility, and thus contributing to an educational environment of excellence.

5. Conclusions

This study aimed to analyze the structure of six schools in the Federal District, using the Degradation Assessment Methodology based on Severity, Urgency, and Trend (GUT). In a comprehensive manner, it was observed that the methodologies provided convergent classifications, indicating the need for maintenance with a similar degree of intervention, each within its specific evaluation criteria. Within the scope of the most critical systems, the study highlighted electrical and plumbing installations, as well as the absence and/or lack of maintenance in the fire protection system and accessibility.

To assist the Post-Occupancy Evaluation (POE) system, it is proposed to conduct detailed inspections of critical systems, carry out necessary maintenance, implement continuous assessments over time, ensure compliance with updated standards, involve end-users in the POE, and develop preventive maintenance plans. These proposals aim to identify problems early, ensuring the compliance and continuous functionality of the built spaces, promoting safe and efficient environments.

In order to validate the effectiveness of this study, the State Department of Education - SEEDF recently announced on its platform that public schools in the Federal District are undergoing maintenance and repairs, focusing on electrical and plumbing systems, and making specific interventions in roofing. This initiative highlights the practical applicability of the recommendations presented, reflecting a tangible commitment to the safety and quality of educational environments.

6. Acknowledgments

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