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Incidence of pathological manifestations and proposition of corrective measures in an Institute of Higher Education in the city of Quixadá/CE

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Abstract: Throughout its use, a building will certainly be exposed to degradation due to external factors, such as the natural effects of climate, and even as a result of misuse. Additionally, errors made during its construction accelerate the deterioration process. Therefore, it is essential to be alert to the performance of buildings, conducting inspections and maintenance using efficient methods at appropriate intervals, in order to minimize the occurrence of pathological manifestations that impact the comfort and safety of users. As a result, this article aims to investigate potential construction-related pathologies through visual inspection at an Institute of Higher Education located in Quixadá, Ceará, Brazil, and propose corrective technical recommendations for the identified pathological manifestations. The study employed an applied research methodology with an exploratory research objective and a qualitative approach. After inspecting and analyzing the collected data, it was found that the building exhibited a high number of pathological manifestations with critical, moderate, and minor risk levels, primarily related to the structural construction system due to ineffective maintenance throughout the lifespan of the building.

Keywords: Public building; Building inspection; Construction pathology.

1. Introduction

Buildings are the most relevant physical spaces for humans, considering the development of activities inherent to their survival, such as work, study, leisure, and housing. Therefore, it is necessary to constantly observe such places, both from a heritage perspective and in relation to factors concerning the safety and comfort of users (IBAPE, 2012).

Despite the constant technological evolution and the improvement of civil engineering practices, constructions still have deficiencies, mainly due to the incidence of pathological manifestations, whether it is non-compliance with regulations, lack of planning, construction defects, or insufficient maintenance throughout their life cycle (CAVALCANTE; SANTANA, 2020).

In this sense, the importance of building inspection, characterized by NBR 16747 (ABNT, 2020), is highlighted as it assesses the technical conditions, use, operation, maintenance, and functionality of buildings and their construction systems and subsystems. Moreover, from an economic and sustainable standpoint, and in favor of preserving life, there is an urgent need to increase the lifespan of existing buildings.

Given the aforementioned context, the overall objective of this research is to perform visual inspections to identify pathological manifestations and propose corrective technical recommendations in an Institute of

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Higher Education (HEI) in the city of Quixadá, CE. Thus, it was necessary to characterize the HEI, conduct an on-site visual inspection, and record the pathological manifestations of the building. The conditions of stability, safety, maintenance, and use of the building were evaluated according to the construction system, and corrective technical recommendations were developed for the identified pathological manifestations.

2. Pathology and pathological manifestations

Historically, the term "pathology" is commonly used in the healthcare field, derived from the Greek terms *"pathos"* meaning disease, and *"logos"* meaning science or study. Therefore, pathology is defined as the science of diseases, representing an abnormal condition in the structure and functioning of living organisms in the medical context (SENA *et al*., 2020).

Similarly, the term "pathology" is used in civil construction to refer to the study of failures and/or anomalies in buildings, which, similar to the human body, are manifested as diseases known as "pathological manifestations" in engineering. These manifestations can originate during the project design stage, construction execution, or over the course of the building's use (OLIVEIRA, M.; OLIVEIRA, T.; ARAÚJO, 2019).

According to Tejo (2018), problems arising from the project design phase can be diverse, including inadequate and incomplete preparation, lack of construction details, incompatibility between systems, incorrect or insufficient information, and the absence of an As-Built project. It should be noted that design errors have an impact on the overall performance of subsequent phases.

During the construction execution phase, construction adversities are primarily caused by low-quality materials, improper material dosage, unskilled and transient labor, and the heterogeneity of construction methods. External factors such as manufacturing errors by subcontracted industries, supplier history, and weather conditions also contribute to these adversities (MITZSUZAKI; SILVA; JESUS, 2019).

Regarding dysfunctions that arise during the building's use phase, they are often a result of prolonged and/or incorrect usage, as well as a lack of maintenance by users or responsible professionals during that period. Therefore, it is important to pay attention to unforeseen overload on the structure, damage to structural elements, and the absence of an adequate maintenance program, as highlighted by Oliveira M., Oliveira T., and Araújo (2019).

It is worth emphasizing that according to ABNT NBR 16747 - Building Inspection - Guidelines, Concepts, Terminology, and Procedure, pathological manifestations are classified as failures or anomalies. Failures are defined as the loss of performance of an element, system, or constructive subsystem due to usage, operation, and maintenance, while anomalies are characterized by the loss of performance of a constructive element, system, or subsystem and can be further divided into:

- Endogenous: when the loss of performance originates from the design and/or execution stage;
- Exogenous: when the loss of performance is related to external factors;
- Functional: when the loss of performance results from natural degradation over time.

Furthermore, the Brazilian Institute of Assessments and Expertise (IBAPE) categorizes failures and anomalies into degrees of risk, as defined by Cavalcante and Santana (2020):

- Minimum degree: represents minor damage related to aesthetics, without threatening the stability or real estate value of the property;
- Medium degree: may cause partial loss of performance and functionality without hindering the direct operation of its systems or promoting early deterioration;
- Critical degree: pose a risk to the health and safety of users, leading to a significant loss of performance and functionality, costly maintenance and recovery, sharp devaluation, impairment of useful life, and possible downtime of the building.

3. Main pathological manifestations in civil construction

According to Helene (1992), it is necessary to study the main pathological manifestations that can affect the construction systems of a building, speculating on their nature, principles, generating factors, and occurrence mechanisms in order to map possible consequences. With that said, the following topics present the most common pathologies in structures, masonry, coatings, plumbing, and electrical installations.

3.1 Pathology in structures

According to Souza and Ripper (2009), the structural system of a building is an extremely complex product of construction, as it presents a wide variety of characteristics that will determine its greater or lesser suitability for the purposes established by the design. Thus, the materials used in the infrastructure and superstructure are diverse, with reinforced and prestressed concrete, steel, and wood being prominent in Brazil.

In general, structures can develop pathological manifestations such as corrosion of reinforcements and steel structures, concrete cracking, infiltration due to expansion joints, deficiencies in waterproofing processes causing stains and cracks, and wood decomposition due to excess moisture or pests such as termites and moths (OLIVEIRA, M.; OLIVEIRA, T.; ARAÚJO, 2019).

3.2 Pathologies in masonry and coatings

According to Sena *et al*. (2020), masonry is usually composed of blocks, joined by a bonding material or simply fitted or overlapped, and it can have a structural function or serve as a partition wall, which also includes coatings on both sides.

Both masonry and coatings can present pathological manifestations, with cracks being the most common, which can occur due to thermal movements, absence or inefficiency of lintels and counter lintels, differential settlements, the presence of projecting structural elements, and lack of wedging. Additionally, there are pathological manifestations caused by moisture (SENA *et al*., 2020).

3.3 Pathologies in electrical and plumbing installations

It is a fact that issues arising from electrical or plumbing installations affect the regularity of other construction processes and systems. Therefore, pathological manifestations originating from water supply, sewage, stormwater, and electrical networks must undergo timely maintenance to avoid compromising masonry, coatings, floors, and structures (SILVA, 2019).

The most recurring pathological manifestations in electrical systems are short circuits, overvoltage, and current leakage, which are directly linked to the use of low-quality materials, finishing defects, loose cables, lack of grounding, and circuit closure errors (SILVA, 2019).

Regarding plumbing systems, pathological manifestations have a direct impact on the comfort, safety, health, and well-being of users, considering their relationship with the physiological needs of each individual (BONE *et al*., 2021). Therefore, the author mentions the occurrence of blockages and pipe leaks as the main issues, mainly resulting from design and execution failures.

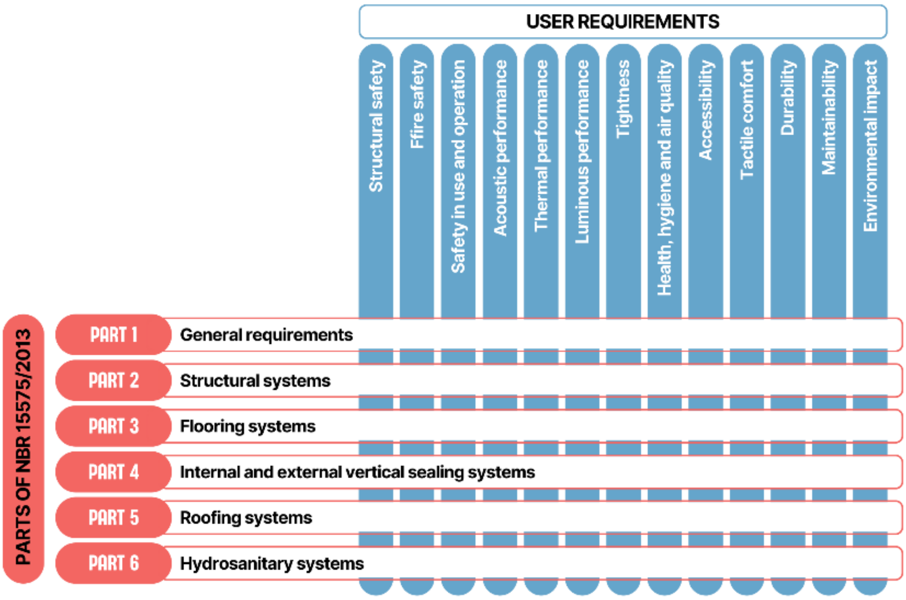
4. Performance standard

ABNT NBR 15575/2013 – Residential Buildings – Performance Standard, commonly referred to as the Performance Standard by professionals in the field, was published in July 2013 after intense discussions and public consultations involving various segments of the construction industry (SENA *et al.*, 2020).

Among the main objectives of the Performance Standard, it establishes criteria to improve performance and safety in residential buildings, aligning with discussions in the field of construction pathology, aiming to reduce the incidence of pathological manifestations (ABNT, 2013).

ABNT NBR 15575/2013 consists of a set of six normative parts, organized based on construction elements, aspects inherent to safety, habitability, and sustainability, while also addressing user requirements, as shown in Figure 1.

Figure 1 – ABNT NBR 15575/2013 Standard Matrix



Source: Adapted from ABNT NBR 15575 Standard (2013)

There are also the concepts of Useful Life (UL) and Useful Life of Project (ULP), which are contained in ABNT NBR 15575 and are essential for a deeper understanding of the standard. According to Souza and Ripper (2009), UL represents the period of time during which the product/construction meets the minimum requirements for performance until it requires interventions and repairs.

ULP, on the other hand, is defined as the age at which the components of a building, as per the project, will meet the technical or subjective requirements imposed on them when exposed to an aggressive environment (SOUZA; RIPPER, 2009). Additionally, the developer, through the project, must indicate the theoretical value for the ULP of the systems that comprise a dwelling, as specified in ABNT NBR 15575-1 (2013), as illustrated in Figure 2.

Figure 2 – Minimum project useful life to be established by the designer

SYSTEM	MINIMUM DESIGN LIFETIME IN YEARS
Structure	According to ABNT NBR 8681/2003
Internal floors	≥13
External vertical fence	≥40
Internal vertical seal	≥20
Roof	≥20
Hydrosanitary	≥20
Considering the periodicity and maintenance processes specified in the respective Use, Operation and Maintenance Manual delivered to the user, prepared in compliance with ABNT NBR 5674.	

Source: Adapted from ABNT NBR 15575 Standard, part 1 (2013)

Therefore, the performance in use of a building and its systems is linked to their useful life, which can be extended or reduced by conducting, or not conducting, technical interventions in pathological manifestations that arise from natural wear and tear and/or accidents (SOUZA; RIPPER, 2009).

5. Inspection and diagnosis

According to Helene (1992), pathological manifestations have a well-defined cause, origin, and mechanism, so understanding them is essential for appropriate treatment. In light of this, inspection becomes a necessary process for building assessment, carried out using a technical methodology, with the purpose of evaluating the conditions of a building based on criteria such as maintenance, depreciation, health and safety of users, functionality, loss of performance, and useful life expectancy (HELENE, 1992).

Among the methods related to inspection, the anamnesis proposed by IBAPE (2012) stands out, which includes the following steps: preliminary inspection, where the professional has the first contact with the object of study and can be divided into levels, as shown in Table 1; historical knowledge of the building, which involves interviews with users and examination of documentation; preparation of guide material, such as plans and/or layouts, to assist with the inspection; official inspection, utilizing appropriate materials and technical knowledge; and preparation of the report.

Table 1 – Inspection level

Level	Characteristics of the place	Types of professionals
1	Buildings with low technical complexity, maintenance, and operation of their elements and construction systems	Qualified in a specialty
2	Buildings with medium technical complexity, maintenance, and operation of their elements and construction systems, with average construction standards and conventional systems	Qualified in one or more specialties
3	Buildings with high technical complexity, maintenance, and operation of their elements and construction systems, with superior construction standards and more sophisticated systems.	Qualified in one or more specialties

Source: Adapted from IBAPE (2012)

In the stage of producing the inspection report, the collected data are organized so that the pathological manifestations are listed, using photos and explanatory captions, which, in most cases, include the classification of the degree of risk. Furthermore, it is possible to diagnose failures and anomalies, meaning to identify and describe their mechanisms, origins, and causes, in order to determine actions to be taken in the short, medium, or long term (SENA *et al*., 2020).

6. Research methodology

This article is defined, according to its nature, as applied research. According to Gil (2017), applied research seeks means for the application and practical use of science, with the aim of expanding the theoretical and technical knowledge of the reader, complementing the base of scientific knowledge.

Regarding the objectives of the study, they fit as exploratory research. Exploratory research seeks to investigate the characteristics of the object of study and provide a general and approximate view of the research problem (GIL, 2017).

The adopted procedures are defined as a case study which, according to Prodanov and Freitas (2013), consists of qualitative and/or quantitative research to obtain more comprehensive information about the various variables inherent to a fact, collecting this data from several sources of evidence.

In addition to the classifications presented, the research has a qualitative approach. Qualitative research allows a deep understanding of the investigated phenomena through detailed and interpretative analysis of the collected data (PRODANOV; FREITAS, 2013).

6.1 Research design

The initial stage of the research consisted of a literature review, seeking the main authors in the field of construction pathology and diagnostic engineering, promoting a detailed study of the types of pathological manifestations in buildings and recommendations for building inspection.

The next step involved selecting the building under study, considering its local and regional relevance. Therefore, a survey of the pathologies present in the building was conducted through an on-site visual inspection, identifying the pathological manifestations, their probable causes, the degree of risk, and the types of anomalies, which were organized by construction systems: masonry; concrete and steel structures; floor, wall, and ceiling coverings; electrical and plumbing installations.

Subsequently, in the third stage, observations and technical recommendations were made based on the manifestations in each construction system. Finally, the most serious problems and their respective corrective actions were presented.

6.2 Characterization of the object under study

The city of Quixadá is located in the Sertão Central of the state of Ceará, Brazil, and has a land area of 2,020.59 km^2. According to the Brazilian Institute of Geography and Statistics (IBGE), it is estimated that there will be 88,899 inhabitants in 2023, resulting in a population density of 39.91 individuals/km^2 (IBGE, 2023).

The municipality of Quixadá/CE has established itself as a tourist destination in the region, offering landscapes and spaces such as the set of monoliths, the sanctuary of Nossa Senhora Rainha do Sertão, the free flight ramp, the Cedro dam, the Estêvão mountain range, among other tourist sites, forming part of its natural and historical-cultural heritage.

It should be noted that the city is also a reference in higher education, as it has universities, colleges, and an academic center, such as the campus of the Federal University of Ceará (UFC), the Federal Institute of Education, Science and Technology of Ceará (IFCE), the Faculty of Education, Sciences, and Letters of the Sertão (FECLESC), the Catholic University Center of Quixadá (UniCatólica), Dom Adélio Tomasin Faculty (FADAT), among others.

Thus, the FECLESC building was chosen as the subject of study, being an institution of higher education located at José de Queiroz Pessoa Street, S/N, Planalto Universitário, Quixadá, CE, Brazil. The building is classified as a medium-standard institutional building with a constructed area of 5,282 m^2 and a total land area of 10,340 m^2. It consists of a ground floor, which includes two blocks of classrooms with ten rooms each, an air-conditioned library, and three auditoriums (Cego Aderaldo, Rachel de Queiroz, and Salão Azul). The upper floor comprises a block with five classrooms. Figure 3 illustrates the main facade of the HEI.

Figure 3 – HEI main facade

Source: Authors (2023)

7. Results and discussions

In light of the context presented, the building under study was analyzed through a visual inspection conducted on July 14, 2022, with the purpose of identifying construction pathologies resulting from failures during the construction and maintenance of the property. It should be noted that this visual inspection is classified as level 1, based on the complexity of the building and the assessors' level of education.

The inspection process was structured according to the construction system and will be presented in the following subsections. To facilitate understanding, the current conditions of each system were highlighted, including the type of anomaly and identified failures. Finally, recommendations and technical advice were provided to address the issues.

7.1 Masonry

The masonry of the institution was constructed to serve as enclosures or divisions of spaces such as classrooms, administrative rooms, cafeteria, library, and auditoriums.

It is worth emphasizing that the oldest block of the building was constructed in 1976, while the other blocks were added as the college expanded, with the construction of the latest classrooms (five classrooms) taking place in 2018.

During the visual inspection, a significant portion of the masonry (walls) was observed to be in conditions that required special attention, as they exhibited pathological manifestations. Thus, the identified anomalies in the masonry were categorized as endogenous, natural, and functional.

Table 2 presents the recorded pathological manifestations in the masonry observed during the building inspection, providing information on the type of manifestation, probable cause, degree of risk, and type of anomaly.

Table 2 – Pathological manifestations in masonry (continued)

	• Pathological manifestation: crack caused by overloading of the masonry; • Causes: insufficient reinforcement; absence of a beam; • Risk level: medium; • Anomaly: endogenous; functional.
	• Pathological manifestation: crack in the masonry; • Causes: error in the execution of the joint between the masonry and the foundation; • Risk level: medium; • Anomaly: endogenous; functional.

Table 2 – Pathological manifestations in masonry (conclusion)

	• Pathological manifestation: repression fissure; thermal movement cracking; • Causes: tensile and shear stresses; hygroscopic movements (humidity by capillary rise); thermal expansion; • Risk level: medium; • Anomaly: endogenous; natural.
	• Pathological manifestation: fissure caused by overloading masonry; • Causes: deficiency in reinforcement; absence of a beam; • Risk level: medium; • Anomaly: endogenous.
	• Pathological manifestation: fissure caused by overloading of masonry; • Causes: crushing of the mortar joints; thermal expansion; • Risk level: medium; • Anomaly: endogenous.
	• Pathological manifestation: vertical cracks due to lack of anchoring with reinforcement between the systems; • Causes: absence of a tie screen; • Risk level: medium; • Anomaly: endogenous.

Source: Authors (2023)

In summary, the identified failures were derived from cracks resulting from overload on the masonry, possibly caused by deficiencies in reinforcements, the absence of a supporting beam, and errors in the junction between the masonry and the foundation (lack of connection between the sealing system and the structural system).

Additionally, there are cracks resulting from soil settlement, thermal movements, tensile and shear stresses, hygroscopic movements (moisture due to capillary rise), and the crushing of the mortar joints.

These construction pathologies can be classified as construction defects (design and/or execution errors), natural degradation of systems (aging) due to the building being 47 years old and not having undergone repairs and maintenance at specific intervals, and natural phenomena, as the city of Quixadá, Ceará, experiences significant thermal movements and seismic activity, which can contribute to the emergence of the mentioned failures.

7.2 Concrete structure

Recurrent pathological manifestations were found in the structural system of the building. In a large number of beams and columns, pathologies related to possible errors during concrete pouring were noticeable, such as improper pouring height and compaction, which were not in accordance with ABNT NBR 14931/2004 - Execution of Concrete Structures - Procedure.

This condition of the system deserves special attention, as structural failures can endanger the lives of building users and impair other construction systems. Consequently, with the incorrect distribution of loads, the masonry may experience excessive loads and window openings may deform, compromising their functionality.

Therefore, the identified anomalies were classified as construction process failures and/or design defects (endogenous), damages caused by natural factors (natural), and natural degradation of the building (functional).

Table 3 provides a photographic record of the pathologies in the concrete structure of the building.

Table 3 – Photographic record of pathologies in concrete structures (continued)

	• Pathological manifestation: detachment and exposed reinforcement; • Causes: inadequate reinforcement cover; improper positioning of the reinforcement; poor concrete quality; • Risk level: high; • Anomaly: endogenous; functional.
	• Pathological manifestation: concrete spalling and exposed reinforcement; • Causes: inadequate reinforcement cover; improper positioning of reinforcement; • Risk level: high; • Anomaly: endogenous.
	• Pathological manifestation: fissures caused by shrinkage; • Causes: inadequate concrete placement; insufficient concrete curing; lack of reinforcement; water infiltration; • Risk level: minimal; • Anomaly: endogenous; natural.

Table 3 – Photographic record of pathologies in concrete structures (conclusion)

	• Pathological manifestation: nest of concreting and exposed reinforcement; • Causes: inadequate reinforcement cover; improper positioning of the reinforcement; • Risk level: high; • Anomaly: endogenous.
	• Pathological manifestation: nest of concreting and exposed reinforcement; • Causes: inadequate reinforcement cover; improper positioning of the reinforcement; • Risk level: high; • Anomaly: endogenous.
	• Pathological manifestation: shrinkage cracks; • Causes: inadequate concrete pouring; inadequate curing of concrete; insufficient reinforcement; infiltration; • Risk level: minimal; • Anomaly: endogenous; natural.

Source: Authors (2023)

Regarding the identified failures in the structural system, concrete delamination, exposure of reinforcements at various points without any protective measures except for superficial painting to conceal the construction defect, and concrete honeycombing were observed. Additionally, concrete was used as a coating for external floors in parts of the building, where shrinkage cracks and significant infiltration were identified.

7.3 Floor, wall, and ceiling cladding

A significant number of masonry walls and floors exhibited recurring pathological manifestations related to moisture. The most recent block was built in 2018 and showed signs of coating deterioration in its access areas, directly affecting its protective, finishing, and waterproofing functions.

The identified anomalies include construction defects (endogenous), damages caused by third parties (exogenous), and damages caused by natural factors (natural).

Table 4 provides a record of the pathological manifestations related to floor, wall, and ceiling finishes.

Table 4 – Pathological manifestation in floor, wall and ceiling coverings (continued)

	• Pathological manifestation: stains and degradation of the coating; • Causes: rising humidity (capillary rise); lack of maintenance; • Degree of risk: minimal; • Anomaly: endogenous.
	• Pathological manifestation: infiltration; • Causes: capillary rise (rising damp); • Degree of risk: minimal; • Anomaly: endogenous.
	• Pathological manifestation: lack of coating; • Causes: absence of finishing after removing a sanitary appliance; lack of maintenance; • Degree of risk: minimal; • Anomaly: exogenous.
	• Pathological manifestation: coating breakdown; • Causes: misuse; possible accident; • Degree of risk: minimal; • Anomaly: exogenous.
	• Pathological manifestation: break in the frame shape; • Causes: misuse; possible accident; • Degree of risk: minimal; • Anomaly: exogenous.

Table 4 – Pathological manifestation in floor, wall and ceiling coverings (conclusion)

	• Pathological manifestation: infiltration; • Causes: water exposure; • Degree of risk: minimal; • Anomaly: endogenous.
	• Pathological manifestation: crack in the floor; • Causes: uncontrolled root growth of nearby trees; • Risk level: medium; • Anomaly: endogenous; natural.
	• Pathological manifestation: peeling of plaster; • Causes: absence of roughcasting; poor mortar quality; lack of maintenance; • Risk level: minimal; • Anomaly: exogenous.

Source: Authors (2023)

Multiple cases of infiltration, stains, coating degradation, and concrete delamination were found, primarily caused by rising damp and water exposure. Additionally, the lack of finishing after the removal of sanitary fixtures, ceramic tile breakage, and frame formwork rupture, possibly resulting from improper installation practices, was observed. Furthermore, cracks were identified in the access floor to the classroom blocks, potentially related to uncontrolled root growth of nearby trees.

7.4 Electrical and plumbing Installations

No pathological manifestations related to the plumbing installations were found. However, concerning the electrical installations, a recurring nonconformity was identified throughout the entire educational establishment.

Specifically, all the air conditioning installations in the building had exposed wiring on the exterior side of the HEI, posing a risk to the lives of students who used the space daily due to the possibility of electric shocks, thermal effects, and overcurrent situations.

Therefore, the identified anomalies are classified as endogenous, resulting from deficiencies in the installation execution.

Table 5 presents the registered pathological manifestations in electrical installations in the building under study.

Table 5 – Pathological manifestation in electrical installations

	• Pathological manifestation: exposed wiring; • Causes: lack of finishing; • Risk level: critical (high); • Anomaly: endogenous.

Source: Authors (2023)

8. Visas and technical recommendations

Through the identification and classification of pathological manifestations, as well as the investigation of the possible origins of these inadequacies in the public building under study, it becomes feasible and, also, essential to propose technical recommendations with preventive and corrective actions based on current regulatory standards.

In this regard, according to the building's construction systems, Table 7 indicates several procedures aimed at addressing the mapped adversities, enhancing the performance of this construction, as well as its lifespan, generating appreciation of the heritage and ensuring the well-being and safety of the users.

Table 6 – Technical recommendations for the building under study (continued)

Construction system	Technical recommendations
Masonry	Observations regarding compliance with its functions of protection, thermal and acoustic insulation, sealing, and division of spaces
	Monitoring the evolution of identified cracks for hairline cracks or larger fissures (cracks with a thickness between 1 mm - 3 mm and above 3 mm, respectively).
	For larger openings that pose a risk to life and are directly linked to the structural system, it is recommended to: use acrylic sealants to fill the grooves; apply polyester mesh with acrylic resin to prevent stretching caused by tensile forces; properly anchor the concrete pillars to the structure and/or secure the cracks on the masonry surface using fasteners
	Treatment of expansion joints to reduce cracks caused by thermal movement
Concrete structures	Coating of exposed reinforcement with anticorrosive material to prevent further damage to the exposed steel
	For the concrete-coated floor, a new application is required. Therefore, it is recommended to use an alternative coating that is better suited to the environmental conditions, such as the use of interlocking blocks
	A more in-depth study of the causes and effects that the existing pathological manifestations can generate is recommended, especially if there are plans for expanding the blocks of the HEI
Floor, wall, and ceiling cladding	Renovation of completely deteriorated coatings, especially those executed with mortar, by removing the old coating and redoing it
	Replacement of fragmented coating with new ceramic coatings
Electrical installations	Isolation of electrical equipment, in addition to protecting the wires, in order to prevent external agents (such as rain, human actions, etc.) from influencing the occurrence of potential tragedies

Source: Authors (2023)

It is worth noting that, according to the Manual of Use, Operation, and Maintenance, prepared in accordance with the ABNT NBR 5674/99 standard - Building maintenance – Procedures (ABNT, 1999), the vertical and horizontal sealing system of IES already exceeds the minimum service life, which should be equal to or less than 40 years for external vertical sealing and equal to or less than 20 years for internal vertical sealing.

Similarly, the ABNT NBR 5674/99 (ABNT, 1999) standard indicates that the cladding system of HEI already surpasses the estimated design service life of 20 years, confirming the need for interventions to address the identified construction issues.

In addition to this, it should be noted that the building is 47 years old, and the design service life of the structural project is 50 years, according to ABNT NBR 15575-1/2013 - Residential buildings – Performance (ABNT, 2013). Therefore, a review of the project, along with maintenance and preventive reinforcements, will be necessary in the coming years.

However, it is essential that these repairs actually take place, considering that problems worsen when left unresolved and that they are carried out by qualified professionals using appropriate technical procedures and materials. Finally, the need for the development of periodic maintenance plans is emphasized.

9. Conclusions

After inspecting the HEI, anomalies and failures were identified in the execution of various construction systems in the property, including issues with masonry, concrete structure, floor, wall, and ceiling finishes, as well as electrical and plumbing installations.

It is crucial to address these anomalies and failures in the mentioned construction systems as they directly impact the building's performance. According to Souza and Ripper (2009), performance refers to the behavior of each product during its service life.

In conjunction with ABNT NBR 15575/2013 - Building Performance, the building must adhere to quality and safety standards (ABNT, 2013). Therefore, it is important to consider the service life of each system, which should be defined during the design phase based on the specific characteristics of each part of the building.

Given the age of the studied building, its service life can be extended or reduced depending on whether maintenance actions are carried out or not. Thus, the need for maintenance interventions and repair of the failures is emphasized to prolong its service life, promoting greater comfort and safety for its users.

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