GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 13, n. 90, 2025

Pathological Manifestations and Damage Map of Historic Buildings: Case Study of the Church of Nossa Senhora do Pilar in Recife/PE

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Submissão: 15/06/2025
Aceite: 31/08/2025
RODRIGUES, Stephany Rayane Silva; LINS , Lívia Campos; SOARES, Willames de Albuquerque; MONTEIRO, Eliana Cristina Barreto. Manifestações Patológicas e Mapa de Danos de Edificação Histórica: Estudo de Caso da Igreja de Nossa Senhora do Pilar em Recife/PE. **Revista Nacional de Gerenciamento de Cidades**, *[S. l.]*, v. 13, n. 90, p. e2501, 2025. DOI: 10.17271/23188472139020256174. Disponível em: https://publicacoes.amigosdanatureza.org.br/index.php/gerenciamento_de_cidades/article/view/6174.

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Manifestações Patológicas e Mapa de Danos de Edificação Histórica: Estudo de Caso da Igreja de Nossa Senhora do Pilar em Recife/PE

RESUMO

Objetivo – Contribuir para a conservação da memória cultural e preservação do patrimônio histórico edificado por meio da análise das manifestações patológicas de uma edificação histórica tombada pelo IPHAN, a Igreja de Nossa Senhora do Pilar.

Metodologia – A análise foi conduzida por meio do levantamento de dados, realização de inspeção visual, mapeamento das manifestações patológicas, representação gráfica por meio de mapa de danos e análise qualitativa e quantitativa das anomalias observadas nas fachadas da edificação, pelo levantamento da cobertura total de danos e do Fator de Danos.

Originalidade/relevância – Aplicação de uma metodologia para análise das manifestações patológicas do patrimônio histórico edificado de forma qualitativa e quantitativa, possibilitando a comparação dos dados e um maior auxílio na tomada de decisão para gestão da conservação, contribuindo, assim, para a preservação material e propagação da memória cultural e afetiva, documentando sua situação atual e fornecendo subsídios para ações de manutenção.

Resultados – Os achados demonstram que essa edificação se apresenta vulnerável a danos externos, especialmente as fachadas Sul (frontal) e Norte (posterior). Segundo as análises qualitativas e quantitativas, as manifestações patológicas mais observadas são, em ordem decrescente, sujidade/biofilme, umidade e intervenção indevida, que podem comprometer a durabilidade dos elementos e o valor histórico da construção.

Contribuições teóricas/metodológicas – A pesquisa demonstra a importância da utilização do mapa de danos para o diagnóstico das manifestações patológicas e da análise quantitativa, que possibilita a comparação das informações entre as fachadas e dados de outras edificações, sendo uma ferramenta útil para auxiliar na gestão da conservação.

Contribuições sociais e ambientais – O estudo contribui para a preservação do patrimônio histórico edificado por direcionar ações de manutenção, que contribuem para a durabilidade do bem e para o aproveitamento deste espaço pela população, podendo atrair, inclusive, recursos financeiros por meio do turismo. Ademais, o restauro é um grande aliado da sustentabilidade, visto que prolonga a durabilidade das construções, mantendo o seu valor e relevância históricos.

PALAVRAS-CHAVE: Patrimônio histórico. Gestão de manutenção. Restauro.

Pathological Manifestations and Damage Mapping of a Historical Building: Case Study of the Church of Nossa Senhora do Pilar in Recife, Brazil

ABSTRACT

Objective – To contribute to the conservation of cultural memory and the preservation of built historical heritage through the analysis of pathological manifestations in a historical building listed by IPHAN, the Church of Nossa Senhora do Pilar.

Methodology – The analysis was carried out through data collection, visual inspection, mapping of pathological manifestations, graphical representation using a damage map, and qualitative and quantitative analysis of the anomalies observed on the building's facades, by measuring the total damage coverage and the Damage Factor.

Originality/Relevance – Application of a methodology for the analysis of pathological manifestations in built historical heritage in both qualitative and quantitative terms, enabling data comparison and providing greater support for decision-making in conservation management, thus contributing to material preservation and the dissemination of cultural and emotional memory, by documenting its current condition and providing a basis for maintenance actions.

Results – The findings show that this building is vulnerable to external damage, especially on the South (front) and North (rear) facades. According to qualitative and quantitative analyses, the most frequently observed pathological manifestations are, in descending order: dirt/biofilm, moisture, and improper interventions, which can compromise the durability of elements and the historical value of the construction.

Theoretical/Methodological Contributions – The research highlights the importance of using the damage map for diagnosing pathological manifestations and the relevance of quantitative analysis, which enables the comparison of information between facades and with data from other buildings, making it a useful tool to support conservation management.

Social and Environmental Contributions – The study contributes to the preservation of built historical heritage by guiding maintenance actions, which enhance the durability of the asset and promote its use by the public, potentially attracting financial resources through tourism. Furthermore, restoration is a strong ally of sustainability, as it extends the lifespan of constructions while maintaining their historical value and relevance.

KEYWORDS: Historical heritage. Maintenance management. Restoration.

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Manifestaciones Patológicas y Mapa de Daños de una Edificación Histórica: Estudio de Caso de la Iglesia de Nossa Senhora do Pilar en Recife, Brasil

RESUMEN

Objetivo – Contribuir a la conservación de la memoria cultural y a la preservación del patrimonio histórico edificado mediante el análisis de las manifestaciones patológicas en una edificación histórica catalogada por IPHAN, la Iglesia de Nossa Senhora do Pilar.

Metodología – El análisis se realizó a través de la recopilación de datos, inspección visual, mapeo de las manifestaciones patológicas, representación gráfica mediante un mapa de daños y análisis cualitativo y cuantitativo de las anomalías observadas en las fachadas de la edificación, mediante el levantamiento de la cobertura total de daños y del Factor de Daños.

Originalidad/Relevancia – Aplicación de una metodología para el análisis de las manifestaciones patológicas del patrimonio histórico edificado de manera cualitativa y cuantitativa, permitiendo la comparación de datos y un mayor apoyo en la toma de decisiones para la gestión de la conservación, contribuyendo así a la preservación material y a la propagación de la memoria cultural y afectiva, documentando su situación actual y proporcionando fundamentos para las acciones de mantenimiento.

Resultados – Los hallazgos demuestran que esta edificación se presenta vulnerable a daños externos, especialmente en las fachadas Sur, frontal, y Norte, posterior. Según los análisis cualitativos y cuantitativos, las manifestaciones patológicas más observadas son, en orden decreciente: suciedad/biofilm, humedad e intervenciones indebidas, las cuales pueden comprometer la durabilidad de los elementos y el valor histórico de la construcción.

Contribuciones Teóricas/Metodológicas – La investigación demuestra la importancia del uso del mapa de daños para el diagnóstico de las manifestaciones patológicas y del análisis cuantitativo, que permite comparar la información entre las fachadas y con datos de otras edificaciones, siendo una herramienta útil para apoyar la gestión de la conservación.

Contribuciones Sociales y Ambientales – El estudio contribuye a la preservación del patrimonio histórico edificado al orientar acciones de mantenimiento, que favorecen la durabilidad del bien y su aprovechamiento por parte de la población, pudiendo incluso atraer recursos financieros a través del turismo. Además, la restauración es una gran aliada de la sostenibilidad, ya que prolonga la vida útil de las construcciones, manteniendo su valor y relevancia histórica.

PALABRAS CLAVE: Patrimonio histórico. Gestión de mantenimiento. Restauración.

GRAPHIC SUMMARY

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1 INTRODUCTION

Built historical heritage plays a fundamental role in shaping the identity of societies, being a symbol of the history of cities, preserving their memory (Bersch *et al.*, 2020). Therefore, as it is a non-renewable resource, its historical value cannot be compromised (Panakaduwa; Coates; Munir, 2024). According to Miran and Husein (2024), the use of modern materials, incompatible with those used in the construction of historical buildings, can be harmful, and therefore materials compatible with the original construction techniques should be used. The conservation of these assets reflects a commitment to sustainability, since they contribute to the economic, social and environmental development of cities (Vasconcelos *et al.*, 2024).

Because these are very old buildings that suffer from the action of several degradation agents, such constructions require maintenance actions to preserve them (Vasconcelos *et al.*, 2024). According to Costa; Silveira; Torres (2021) and Costa *et al.* (2024), facades are the elements that suffer most from the action of bad weather and, therefore, the correct diagnosis of pathological manifestations, as well as the execution of adequate maintenance activities, are essential to ensure that existing faults do not worsen and compromise the durability of the building.

Amorim *et al.* (2023) stated that carrying out periodic inspections, associated with the systematic recording of damages, through mapping and recording of damages, contributes to the management of the maintenance and conservation of the built heritage. Resende *et al.* (2022) recommended annual inspections after major maintenance actions to monitor and identify faults that may compromise the useful life of the building. The lack of maintenance actions can contribute to the emergence and worsening of pathological manifestations, compromising the historical heritage of buildings (Costa; Torres, 2021). Rodrigues *et al.* (2023) explain that the development of a database with detailed and accurate records of the conservation status of a building can help identify patterns and trends, enabling the prediction of future problems and, consequently, the planning of preventive maintenance.

The damage map is a tool that contributes to the diagnosis of pathological manifestations and the preparation of the maintenance (Bersch *et al.*, 2020; Costa *et al.*, 2024; Vasconcelos *et al.*, 2024). The application of methods for quantitative damage analysis allows the comparison of the conservation status of facades, thus guiding maintenance actions, as well as monitoring the evolution of damage (Verdum *et al.*, 2021). Furthermore, the use of qualitative and quantitative indicators provides satisfactory results on the state of degradation without causing damage to buildings and with low execution costs (Costa; Torres, 2021).

Climate change can contribute to the degradation of building materials, especially when it comes to historic buildings, due to the age of their construction elements (Cavalagli *et al.*, 2019). Therefore, some studies seek to establish a relationship between the influence of the incidence of inclement weather, depending on geographic orientation, and the occurrence of pathological manifestations (Mazer, 2016; Costa; Silveira; Torres, 2021).

2 OBJECTIVES

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This study aimed to contribute to the conservation and preservation of the historical heritage through the study and analysis of the pathological manifestations of the facades of the Church of Nossa Senhora do Pilar, located in Recife/PE, documenting its current state of conservation and providing support for maintenance actions.

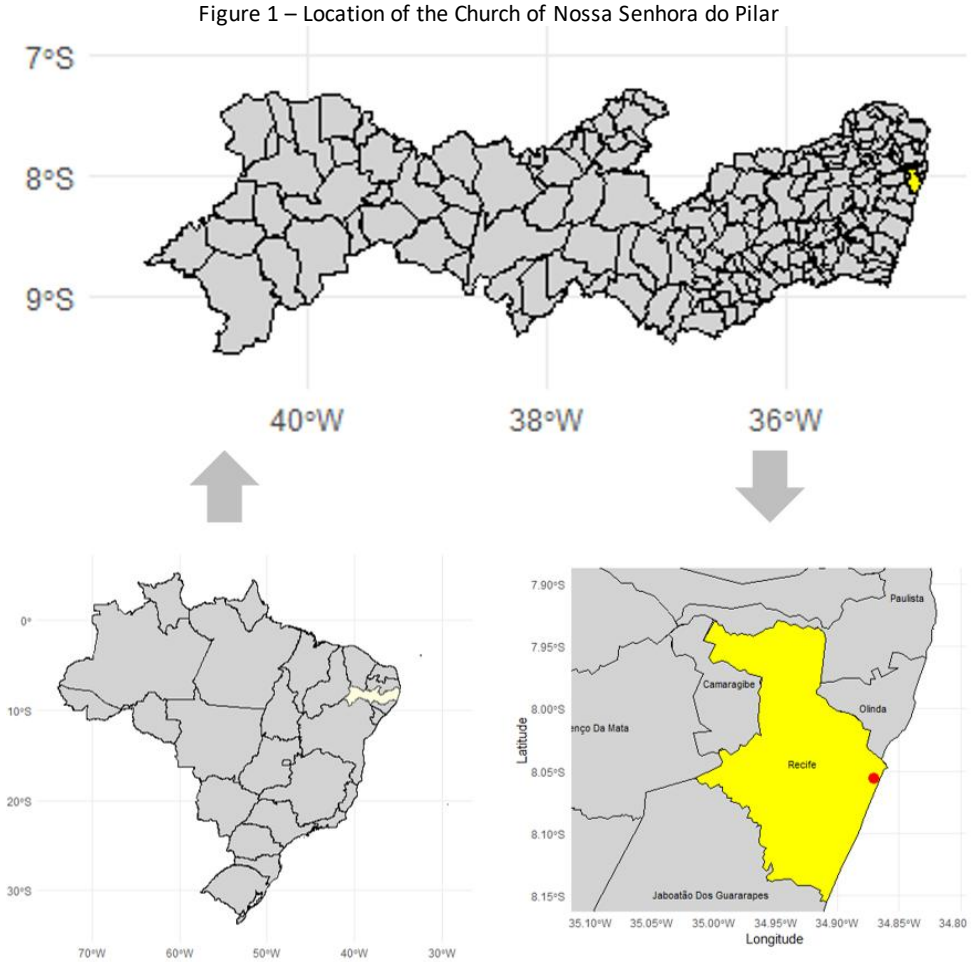
3 METHODOLOGY

The methodological procedure for the development of this study was divided into three parts: presentation of the object of study, data collection and measurement of degradation.

2.1 Object of study

The Church of Nossa Senhora do Pilar, located at Praça Nossa Senhora do Pilar, in the Bairro do Recife/PE neighborhood (Figure 1), was listed by the National Institute of Historical and Artistic Heritage (IPHAN), together with its valuable collection, in 1965 (IPHAN, 2025). The region under study is defined as As by the Köppen climate classification system (Medeiros *et al.*, 2018).

Figure 1 – Location of the Church of Nossa Senhora do Pilar



Source: Authors.

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The construction of the Church began in 1679, through the donation of the lands where the São Jorge Fort had stood, to Captain-Major João do Rêgo Barros, with the specific purpose of founding the temple (Guerra, 1970; Silva, 2006). During its construction, completed around 1683, materials from the demolition of the Fort, such as bricks, stones and walls, were used (Guerra, 1970). After the completion of the works, a village developed around it, which, until the demolition of the Arco do Bom Jesus in the mid-19th century, was separated from the urban center to the south, in the region known as Fora-de-Portas (Silva, 2006).

According to Guerra (1970), the original construction was marked by the semi-spherical vault of the main chapel, covered in rare tiles, and the image of the patron saint on the main altar, which was genuinely Portuguese. According to the author, the exterior of the temple underwent several modifications, such as the addition of a tower on the West Facade, with the largest intervention being carried out between 1898 and 1906, with the help of residents of the Fora-de-Portas region, after which the temple was definitively opened to the public.

According to Silva (2008), at the beginning of the 20th century, a large part of the region around the Church of Nossa Senhora do Pilar was expropriated to serve as port facilities, which did not go ahead, resulting in an irregular occupation called the Pilar Community. The author also states that in 1991, the Revitalization Plan was created in order to promote tourism in the neighborhood and, from 1998 onwards, through the Monumenta Program, the Municipal and Federal Governments invested in the requalification of the area. Therefore, the building and its surroundings suffered from the impact of the urban remodeling processes and, later, when the project was not implemented, the lack of use and maintenance contributed to the collapse of its roof and to the actions of vandals, who carried out looting and vandalism, which intensified between 2001 and 2008 (IPHAN, 2013).

In 2008, the church underwent a complete restoration process, which lasted four years and cost approximately R$ 1.4 million (IPHAN, 2013).

2.2 Data collection

The building under study was selected based on the analysis of the following criteria: listing by IPHAN; relevance to society; ease of access for inspections; and availability of information and data about the property. The fact that it is located in a location with little visibility, as well as its state of disrepair, were determining factors in its selection.

The study began with a bibliographical survey and consultation of the collections of the agencies responsible for preserving historical heritage. At this stage, the architectural survey of the building under study was made available, which allowed us to prove its social relevance. Technical inspections were then carried out with the aim of verifying the data obtained from the facades and mapping the pathological manifestations of these in the buildings. To this end, sketches were prepared to record the faults for each facade and photographic records were obtained for better understanding. The due diligence took place in April 2025. After analyzing the information, a damage map for each facade studied was developed using AutoCAD software. To analyze the influence of solar incidence and winds on the occurrence of pathological manifestations, the solar chart and the wind rose of the city of Recife were studied using SOL-AR software.

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2.3 Measuring degradation

In order to quantify the occurrence of pathological manifestations, two methods were used: the calculation of damage coverage, used in the works of Costa; Silveira; Torres (2021) and Nascimento et al. (2024), and the calculation of the damage factor (FD), based on the works of Silva (2014), Costa; Silveira; Torres (2021) and Costa *et al.* (2024).

Damage coverage consists of the relationship between the area affected by a given pathological manifestation and the total area of the facade (Costa; Silveira; Torres, 2021). The FD represents the degree of incidence of a given anomaly (Costa *et al.*, 2024). To obtain this parameter, a 0.50m x 0.50m mesh was superimposed on the damage map of each facade, starting from the lower left corner, and a simple count of the mesh units affected by each failure was performed. Then, the relationship between the area compromised by each anomaly and the total area under study was calculated, for each orientation of the envelope (Equation 1).

$$FD = \Sigma Ad(n)/At \quad \text{(Equation 1)}$$

Where:

$Ad(n)$ = Area degraded by a pathological infestation n, in square meters (m²)

At = Total area of the facade, in square meters (m²)

5 RESULTS

5.1 Solar and wind incidence

By studying the solar chart and the wind rose, it was possible to conclude that the North and South facades receive sunlight throughout the day, but at different times of the year: the North facade receives it mainly between March and September, while the South facade receives it between September and March. The East and West facades receive sunlight throughout the year: the first, in the morning, until 12:00 p.m., and the second, in the afternoon, from 12:00 p.m. The South and East facades receive the greatest incidence of winds, which hit the South, North and East facades at greater speed.

5.2 Damage Map

Analyzing the damage map and the pathological manifestations of the building's facades (Figures 2 and 3), one can notice the incidence of dirt/biofilm, mainly in the most prominent elements of the facade and in the lower and upper regions; moisture stains; and the occurrence of improper interventions.

On the North Facade, it is possible to observe the formation of dirt/biofilm resulting from the runoff of rainwater from the facade, in greater quantity in areas where there is no protruding ornament at the top. This fact proves the influence of architectural elements on the development of anomalies pointed out by Bersch *et al.* (2020), as well as their relationship with sources of humidity, rain and wind. According to Prieto *et al.* (2017), humidity is identified as the

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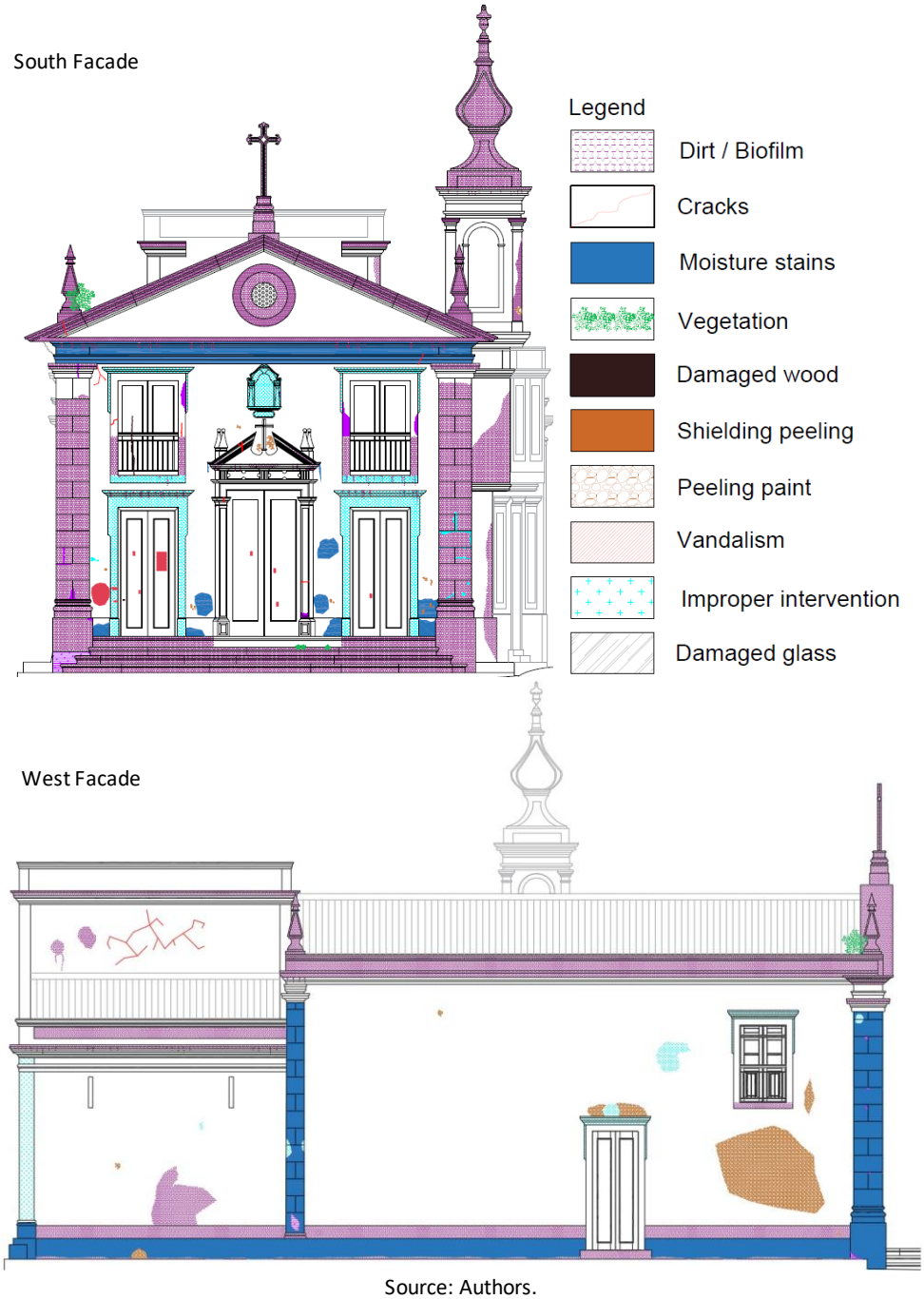
main cause of pathological manifestation in historic buildings, and is a factor that must be controlled to contain the advance of degradation.

Improper interventions are caused by the application of paint to stonework, the apparent use of cement components, in disagreement with the recommendations in the restoration project, or holes made in stonework. Moisture stains are caused by rising damp or by the accumulation of moisture in ornaments located in the upper region, as discussed by Bersch *et al.* (2020).

Figure 2 – Damage Maps of the South and West Facades



Source: Authors.

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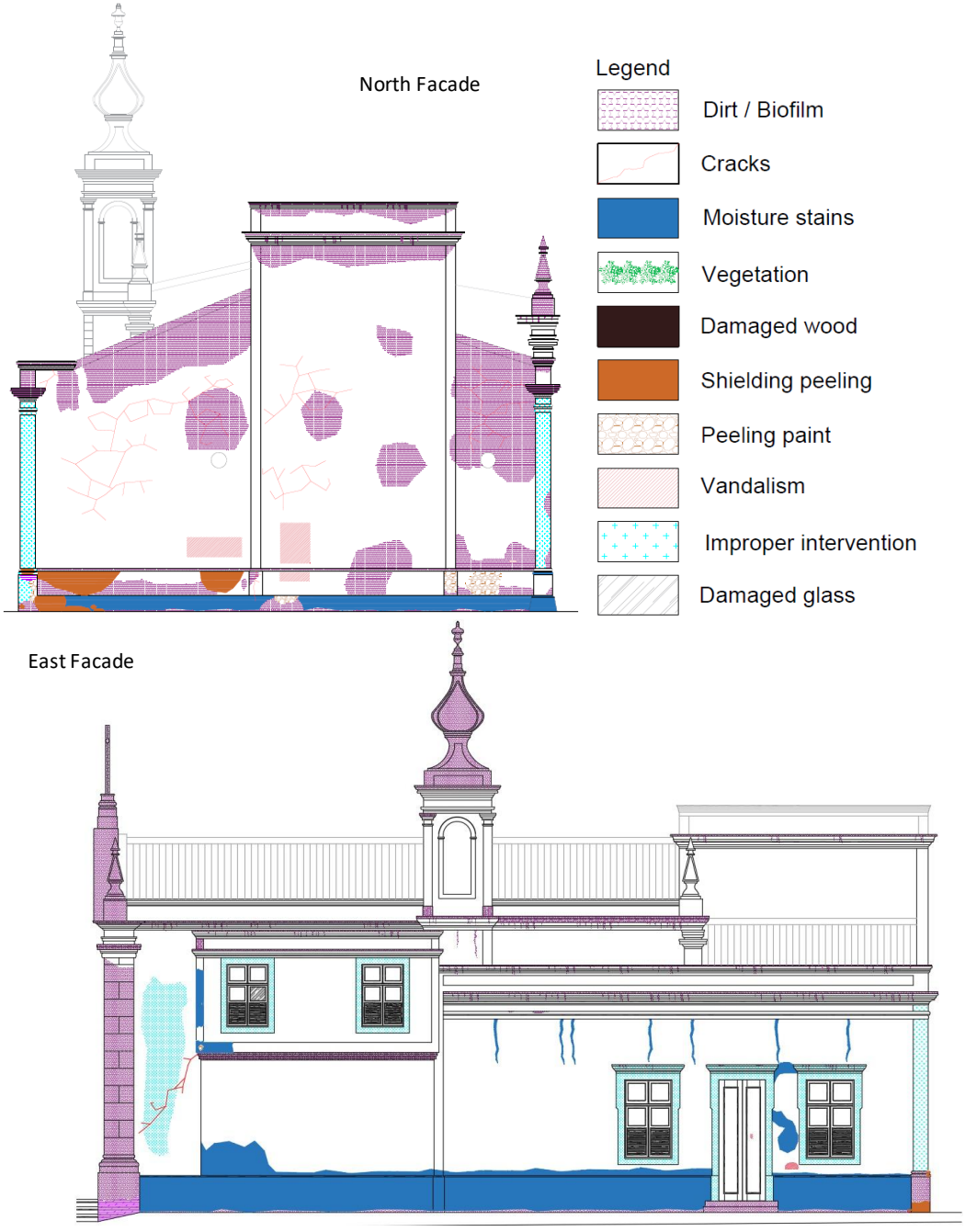
As in the study by Amorim et al. (2024), the building under study did not present significant structural damage. The cracks and fissures apparent in the damage maps were identified at the meeting of materials — caused by differences in deformations — in stonework and in sections of continuous wall, the latter case being observed mainly on the North Facade. Vegetation growth can be noted near stonework elements, which must present some crack or high porosity and water accumulation, especially on the North Facade, in the lower and top left regions.

Figure 3 – Damage Maps of the North and East Facades



Source: Authors.

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The damage to the wood identified corresponds to cracks or small openings in the frames. The peeling of the cladding affected the North Facade of the building most intensely, probably due to a faulty construction associated with the presence of humidity. The peeling of the paint is more evident on the West and North Facades.

Vandalism was noted in the lower regions of the facades, where drawings, political propaganda stickers and even lipstick marks were identified. Only one damaged window was identified on all four facades, located on the East Facade.

5.3 Measuring degradation

According to the calculation of damage coverage (Table 1), the most recurrent pathological manifestations in the building were dirt/biofilm, moisture stains, and improper intervention. The South facade (Figure 4) presented the highest percentage of occurrence of anomalies, 38.15%, according to the result obtained by Nascimento *et al*. (2024), followed by the North Facade (Figure 5), with a percentage of 36.54%. The most frequent pathological manifestations on these facades were the same as those identified for the building as a whole, with only the occurrence of displacement of the coating and vandalism on the North Facade being worth highlighting.

Table 1 – Damage coverage of the facades of the Church of Nossa Senhora do Pilar

Pathological manifestation	South Facade	North Facade	West Facade	East Facade
Dirt/biofilm	25,93%	25,91%	13,00%	8,71%
Moisture stains	5,85%	3,72%	8,99%	10,62%
Improper intervention	5,53%	3,05%	1,60%	5,64%
Peeling paint	0,01%	0,77%	2,54%	0,01%
Vandalism	0,32%	1,50%	-	0,03%
Shielding peeling	-	1,60%	-	0,08%
Material degradation	0,46%	-	0,05%	0,25%
Damaged glass	-	-	-	0,07%
Vegetation	0,05%	-	-	-
Damaged wood	0,01%	-	-	-
Total	**38,15%**	**36,54%**	**26,18%**	**25,40%**

Source: Authors.

According to Bersch *et al*. (2020) e Rocha; Carneiro; Monteiro (2023), south-facing building facades are exposed to a higher incidence of rain and wind and only receive sunlight for a period of 9 months in a year, which contributes to the preservation of moisture on the facade, which, according to Prieto *et al*. (2017), is the main causative agent of anomalies in historic buildings. Mazer *et al.* (2016) highlighted the higher occurrence of infiltrations on facades exposed to higher incidence and wind speed, relating the orientation of the facade with the occurrence of damage caused by moisture. However, Costa; Silveira; Torres (2021) did not statistically demonstrate the relationship between the orientation of the facades and the occurrence of anomalies.

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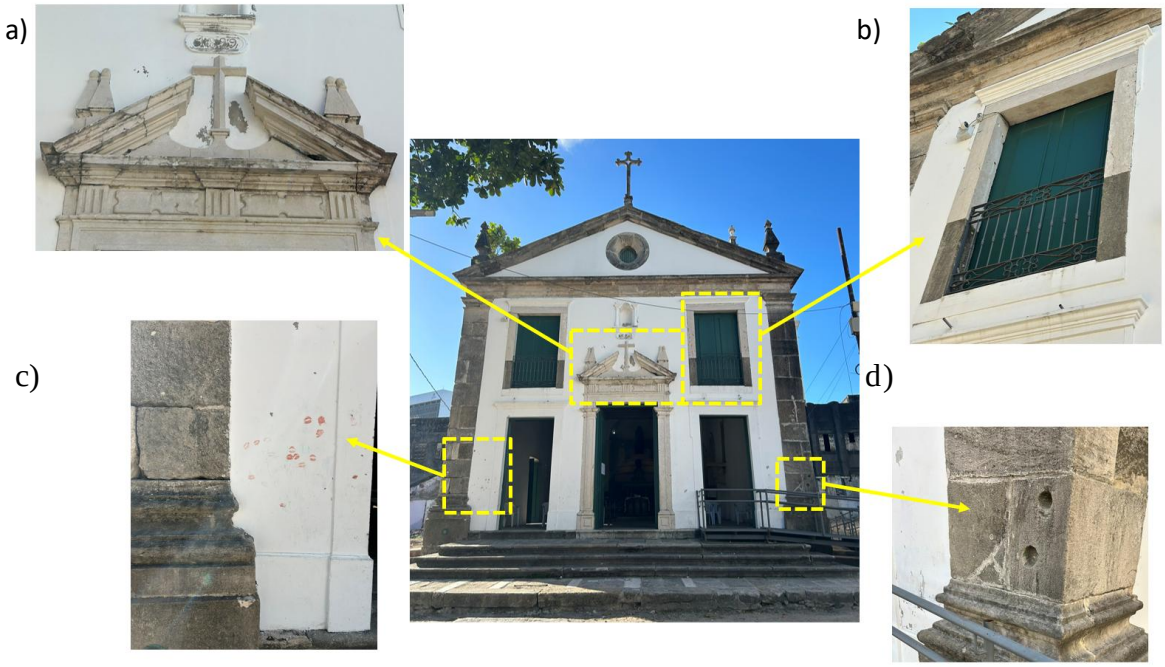
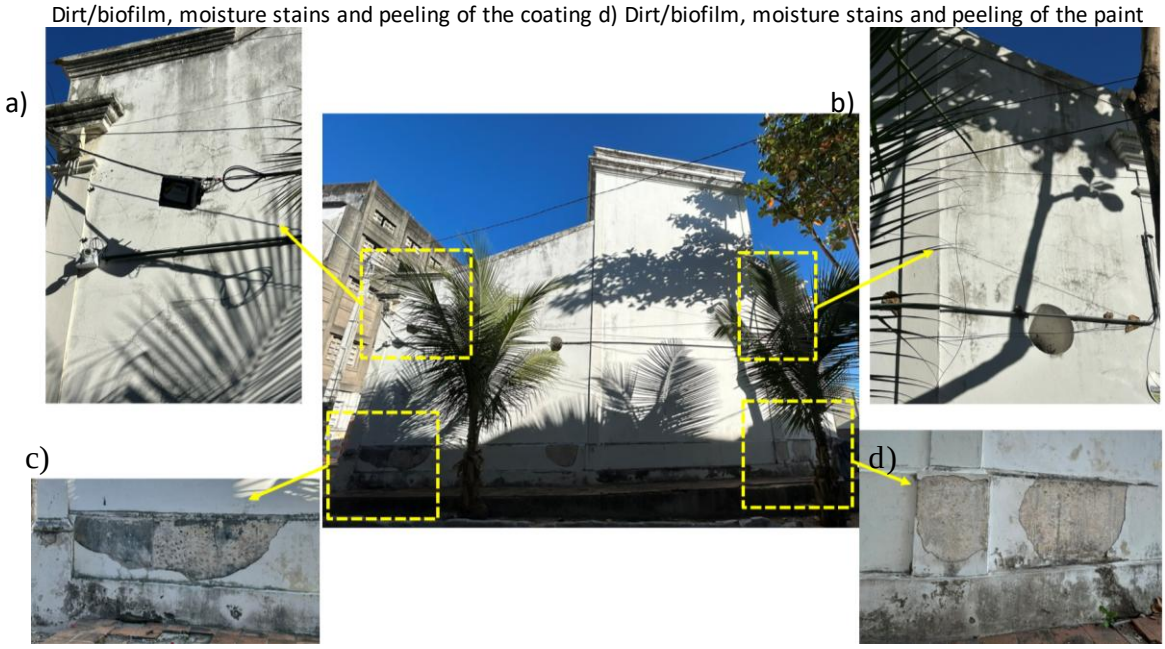
Figure 4 – Pathological manifestations of the South Facade: a) Dirt/biofilm, peeling paint, cracks b) Undue intervention, dirt/biofilm, material degradation c) Dirt/biofilm, vandalism d) Undue intervention, dirt/biofilm



Source: Authors.

Figure 5 – Pathological manifestations of the North Facade: a) Dirt/biofilm, cracks b) Dirt/biofilm, cracks c) Dirt/biofilm, moisture stains and peeling of the coating d) Dirt/biofilm, moisture stains and peeling of the paint



Source: Authors.

Analyzing the results of the Damage Factor (Table 2), the pathological manifestations with the most significant indices were the same ones observed in the calculation of damage coverage: dirt/biofilm, moisture stains and improper intervention. The South and North facades presented the greatest degradation results; however, the West facade presented the best state

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of conservation in this method, a different result from that obtained previously, when the East facade presented less significant degradation values.

Table 2 – Damage factor of the facades of the Church of Nossa Senhora do Pilar

Pathological manifestation	South Facade	North Facade	East Facade	West Facade
Dirt/biofilm	0,56	0,56	0,32	0,32
Moisture stains	0,09	0,06	0,19	0,15
Improper intervention	0,22	0,06	0,22	0,04
Peeling of paint	0,03	0,02	-	0,06
Vandalism	0,03	0,04	0,01	-
Shielding of coating	-	0,05	0,01	-
Material degradation	0,04	-	-	0,01
Damaged glass	-	-	-	-
Vegetation	0,01	-	-	-
Cracks	0,03	0,17	0,01	0,02

Source: Authors.

As in the study by Mazer *et al.* (2016), the highest occurrence of cracks and peeling of the coating occurred on the North facade using both methods. The presence of three trees close to this facade may favor the accumulation of moisture by not allowing direct sunlight in certain regions, contributing to the emergence of pathological manifestations related to moisture, since this facade also does not receive sunlight throughout the year, making it difficult to dry.

According to Costa *et al.* (2024), the damage factor makes it possible to count the area of influence of the pathological manifestation. From the results, it can be noted that the most expressive anomalies obtained a higher indicator using the method, thus increasing the results, as also evidenced in the study by Costa; Silveira; Torres (2021). Another difference between the methods is the possibility of counting areas affected by cracks through the application of the FD; since the collection of information is standardized. However, Costa; Torres (2021) points to the damage map as the most reliable method, as it contains a faithful representation of all pathological manifestations.

5 CONCLUSIONS

The most common pathological manifestations in the Church of Nossa Senhora do Pilar are dirt/biofilm, moisture stains and improper intervention. The South and North facades are in the worst state of conservation and therefore require priority intervention, since no more serious occurrences were observed on the other facades, albeit on a smaller scale.

The analysis of the damage map made it possible to identify a certain pattern in the occurrence of pathological manifestations, such as accumulation of dirt in more prominent regions of the facade; moisture stains in the lower and upper regions; evidence of vandalism in the lower regions, due to easy access; growth of vegetation in stonework elements; occurrence of cracks at the junction of materials and in continuous wall planes; and improper intervention

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in stonework elements. Therefore, the damage map is shown to be a valuable tool for diagnosing pathological manifestations and planning intervention and restoration actions.

Quantifying damage allows for a more critical analysis of the conservation status of the facades, enabling an understanding of the most recurrent pathological manifestations and the facades in a more critical state, which also contributes to conservation management. A technique for surveying cracks using the damage coverage method or the use of a smaller mesh to calculate the Damage Factor could provide more accurate values for these surveys, and this is a suggestion for future work.

This study provides valuable information about the conservation status of the Church of Nossa Senhora do Pilar, enabling the planning of restoration actions. In addition, it applies and compares effective techniques for analyzing and monitoring pathological manifestations, which can be used for study and comparison with other buildings and for conservation management.

6 ACKNOWLEDGEMENTS

This research was supported by the Foundation for Science and Technology Support of the State of Pernambuco (FACEPE) and the National Council for Scientific and Technological Development (CNPq).

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GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

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STATEMENTS

CONTRIBUTION OF EACH AUTHOR

When describing each author's contribution to the manuscript, use the following criteria:

- **Study Conception and Design**: Stephany Rayane Silva Rodrigues and Willames de Albuquerque Soares had the central idea for the study and helped define the objectives and methodology.
- **Data Curation**: Stephany Rayane Silva Rodrigues and Lívia Campos Lins organized and verified the data to ensure its quality.
- **Formal Analysis**: Stephany Rayane Silva Rodrigues and Lívia Campos Lins performed the data analysis, applying specific methods.
- **Funding Acquisition**: The financial resources required for the study were obtained from the Graduate Program in Civil Engineering and the University of Pernambuco, the Foundation for Science and Technology Support of the State of Pernambuco (FACEPE) and the National Council for Scientific and Technological Development (CNPq).
- **Investigation**: Stephany Rayane Silva Rodrigues and Lívia Campos Lins conducted the data collection.
- **Methodology**: Stephany Rayane Silva Rodrigues and Willames de Albuquerque Soares developed and adjusted the methodologies applied in the study.
- **Writing - Initial draft**: Stephany Rayane Silva Rodrigues wrote the first version of the manuscript.
- **Writing – Critical Review**: Willames de Albuquerque Soares and Eliana Cristina Barreto Monteiro reviewed the text, improving clarity and coherence.
- **Review and Final Editing**: Stephany Rayane Silva Rodrigues reviewed and adjusted the manuscript to ensure it complies with the journal's standards.
- **Supervision**: Willames de Albuquerque Soares and Eliana Cristina Barreto coordinated the work and ensured the overall quality of the study.

DECLARATION OF CONFLICTS OF INTEREST

We, Stephany Rayane Silva Rodrigues, Lívia Campos Lins, Willames de Albuquerque Soares and Eliana Cristina Barreto Monteiro, declare that the manuscript entitled "Pathological Manifestations and Damage Map of Historic Buildings: Case Study of the Church of Nossa Senhora do Pilar in Recife/PE":

1. **Financial Relationships**: No financial relationships that could influence the results or interpretation of the work.
2. **Professional Relationships**: No professional relationships that could impact the analysis, interpretation or presentation of the results.
3. **Personal Conflicts**: No personal conflicts of interest related to the content of the manuscript.