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

ISSN 2318-8472, v. 12, n. 85, 2024

Pathological manifestations on hospital unit facades: case study at the appointment center of the Oswaldo Cruz University Hospital, Recife - PE

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

ISSN 2318-8472, v. 12, n. 85, 2024

SUMMARY
Facades separate the internal environment from the external environment of a building, being the element that suffers most from the action of environmental agents and, therefore, requires monitoring to guarantee its performance. In this analysis and recording process, the Damage Map can be a valuable technique as it deals with a set of documents that graphically represent problems presented by construction. With the aim of expanding the applicable contexts for the Damage Map and promoting a contribution to the University of Pernambuco, the present research aimed to determine the pathological manifestations occurring on the facades of the marking center block of the Oswaldo Cruz University Hospital, Recife -PE, see the presentation of their respective Damage Maps and corrected region damage factors (FDrc). The methodology involved carrying out research into the history of the building, field inspections with the aid of a fissurometer, laser tape measure and pacometer and the application of equations to calculate the FDrc in order to have a quantitative analysis. With the development of the study, it was found that the Damage Map technique has value in helping to make decisions for the maintenance plan, that with the calculation of damage factors it is possible to evaluate the degradation in relation to the regions of the facades, with the identification of possible factor relationships, and that the most common pathological manifestations were mold, mildew and dirt.

KEYWORDS: Pathology in Civil Construction. Damage Map. Hospital facade.

1 INTRODUCTION

Building inspection aims to assess the quality of a building by evaluating identified pathological manifestations; (GOMIDE et al., 2020) among the items that must be considered in expert analysis are the facades. According to Santos et al. (2018), the facade, which is part of the building envelope, that amins to separate the exterior and interior environments, is the first impression of a construction. With a significant aesthetic weight, it is the element that is most affected by the action of aggressive agents from the environment, compromising its performance over its lifespan. This, in turn, is defined by NBR 15.575-1 (ABNT, 2021) as the period during which the building and its systems are available for the functions for which they were designed and built, meeting the performance levels that the standard specifies. Therefore, facades deserve monitoring to guarantee the maintenance of activities and the consequent lifespan with the conservation of the property.

According to Madureira et al. (2017), to assess the durability performance of a facade, it is necessary to know and to understand the agents that can damage it. Pathological manifestations originate from failures that occurred during one or more phases of a building, which can be in the design, execution, or use phase. These failures are intensified by aggressive agents, such as wind and humidity, for example, which often act in combination (ROCHA, 2017). Thus, it is fundamental to study the pathological manifestations incident on facades, as well as their origins and mechanisms.

Pathology, under Civil Engineering point of view, can be understood as the segment that studies the symptoms, mechanisms, causes, and origins of failures in civil constructions; in other words, it is the study of the parts that make up the diagnosis of the problem (HELENE, 1992; BOLINA; TUTIKIAN; HELENE, 2019). Analogous to the human body, buildings are susceptible to diseases, which can worsen and lead to emerge other illnesses, or even death, which, in this case is collapse. Thus, studying pathologies is important to understand the evolution of manifestations, investigate their causes and mechanisms, provide information to

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repair and schedule maintenance services, and so contribute to understand the production and post-production process, minimizing the occurrence of problems (MONTEIRO, 2019).

Throughout the study and documentation process, damage mapping can be a valuable tool. It can be formed by a set of photographs, graphs, and documents, damage maps comprise the graphical representation and knowledge of the construction's damages (HAUTEQUESTT FILHO; ACHIAMÉ, 2018). According to Barthel, Lins, and Pestana (2009), it is a technique that has not yet fully explored its potential. Without standards regulating its use and terms and with the gradual growth of scientific publications, it becomes increasingly important to develop studies that employ this technique in different contexts to build an acquis.

2 OBJECTIVES

In order to determine the pathological manifestations occurring on the facades block at the contact center scheduling at Oswaldo Cruz University Hospital (HUOC) in Recife, Pernambuco and to present their respective Damage Maps and calculation of damage factors corrected by regions. The aim is to provide an expansion of contexts for the use of damage maps and contribute to the University of Pernambuco (UPE), favoring more assertive decision-making regarding the maintenance of the state's heritage.

3 METHODOLOGY

This section presents the procedures used to develop this research, including data collection, mapping of pathological manifestations, and measurement of degradation.

3.1 Study Area

In 1858, Provincial Law No. 450 was sanctioned by then-president of the Province of Pernambuco, Benvenuto Augusto de Magalhães, which determined the installation of the Brotherhood of Mercy in Recife. Thus, on July 29, 1860, the official Santa Casa da Misericórdia do Recife installation's (Holy House of Mercy of Recife) took place and on August 6th in the same year, the Santa Casa da Misericórdia de Olinda was incorporated into it. With the mission of providing health care, new health units were established in the city under its administration, one of which was the Hospital de Santa Águeda in 1884, currently Oswaldo Cruz University Hospital (SANTA CASA DE MISERICÓRDIA DO RECIFE, 2023; FLOR, 2018).

Figure 1 - It shows the hospital's structure in its first decades of operation.

Sources: Villa Digital, Fundação Joaquim Nabuco (2023)

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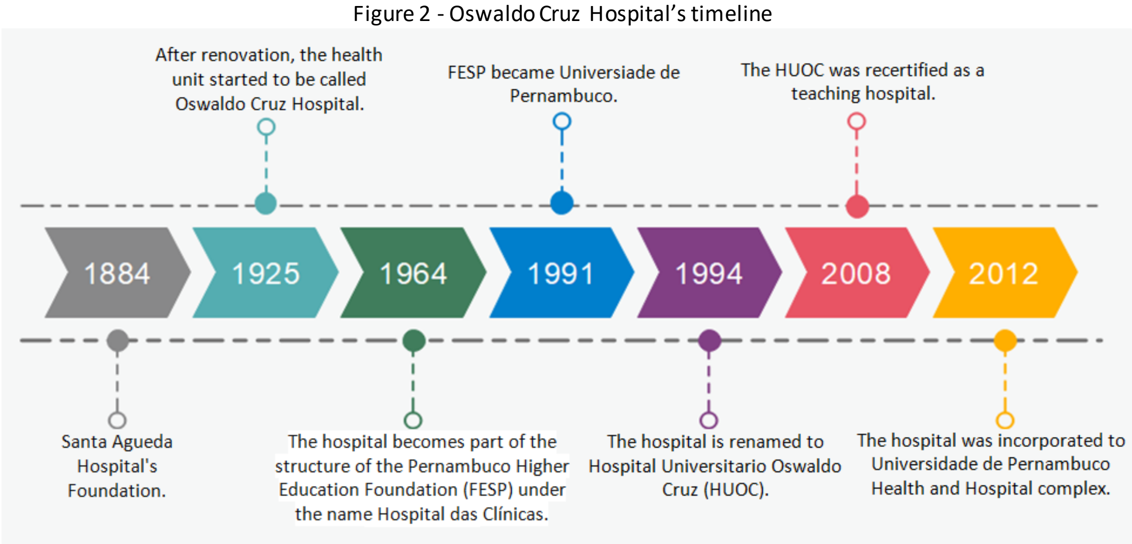
In order to combat the epidemics that plagued Recife in the mid-19th century, such as malaria, tuberculosis, dysentery, and syphilis, as well as the dreaded smallpox, Santa Águeda Hospital was built in Santo Amaro in an area near the neighborhood cemetery with two well-ventilated buildings: one for women, the other for men and a chapel. In 1925, the hospital underwent a renovation that resulted in the expansion of its structure to ten pavilions, two blocks for surgeries, four permanent intensive care units and a chemotherapy center. At this point, it became known as Oswaldo Cruz Hospital, as a tribute to the doctor and researcher who was a reference in the areas of epidemiology and public health in Brazil. Over the decades, the hospital underwent through changes and Figure 2 shows a timeline with the condensation of historical information.

Belonging to Health District I of the Recife Health Department, HUOC is the oldest and largest in terms of clinical specialties at the University of Pernambuco Hospital Complex. With 18,000 m² of built physical structure, it has more than 400 registered beds, including pediatric and adult oncology, infectious and parasitic diseases, intensive care units (ICU), and liver transplants. Serving as a reference for epidemiological risks and team formation for assistance, it participates in the National Clinical Research Network and in the committees for creating protocols for infectious diseases (UNIVERSIDADE DE PERNAMBUCO, 2023).

Figure 2 - Oswaldo Cruz Hospital's timeline



Source: authors

Within the large territorial area of the HUOC, there are several buildings that make the lot quite occupied. With different architectural forms, it is possible to observe that most of the buildings do not exceed two floors, the most discordant being the Pediatric Onco-Hematology Center (CEONHPE), which has seven floors and is one of the most recent. This architectural heterogeneity indicates that the buildings were constructed as new functions and consequent needs were incorporated into the hospital (FLOR, 2018).

Considering that for ceramic tiles, it is extremely important to perform tactile inspections, which require work at height and consequent additional cost, they were not considered for the selection of the object of study of the present research. Finally, also

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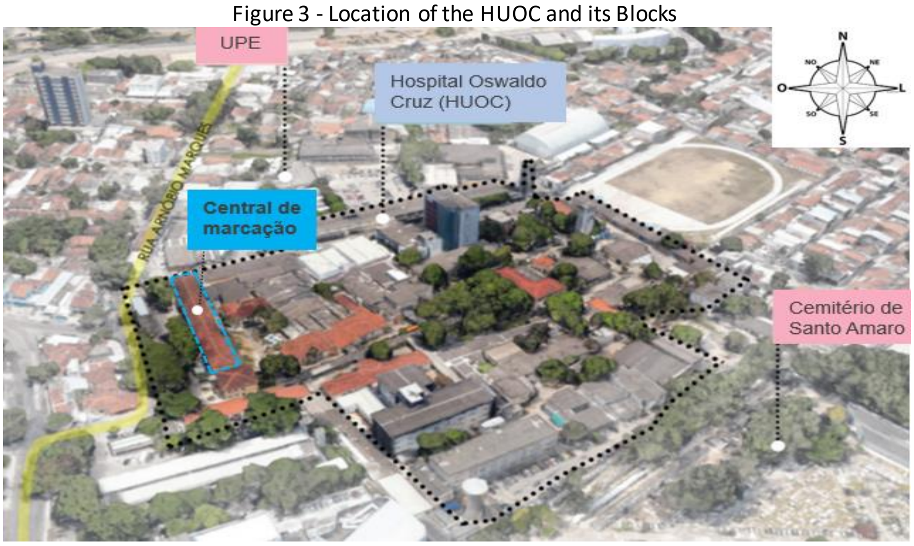
considering the function, position, and state of conservation, the block that comprises the marking and palliative care center was selected. Figure 3 shows the location of the HUOC and the positioning of the study block.

Figure 3 - Location of the HUOC and its Blocks



Source: authors

3.2 Data collection and pathological manifestations' mapping.

Initially, a letter of consent was requested from the hospital's board of directors, whose process began in December 2022 and was granted in March 2023. After authorization for the development of the dissertation at the institution, a contact was formed with the HUOC engineering team, in order to obtain information about the block and settle the dynamics of the inspections. With this team, a version of the architectural project of the floor plan and one of the facades of the block was obtained, which, after analysis, needed adjustments, since they were not consistent with reality. The process was carried out with the aid of a FLC laser tape measure, with a range of up to 80m.

In order to detect and record the problems in the facades, visual inspections were carried out. As an aid to the diagnosis of the problems, the fissurometer equipment was used, to verify the size of the openings, and a pacometer, model ws120 from Nicetymeter, to identify the location of the structural elements. The entire photographic record was carried out through the Samsung A53 5G smartphone. AutoCAD software was used to make both the adjustments to the façade designs and the Damage Map. The hatches and colors adopted for the graphic representation of pathological manifestations were defined following the work of Cavalcanti (2022).

3.3 Measuring degradation

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Aiming at a quantitative and comparative analysis between the facades, considering the cardinal positioning, surroundings and degradation agents, the Damage Factor (FD) of the facades was calculated, based on the work of Santos (2018). This parameter informs the degree of incidence of pathological manifestations and can be defined as the sum of the area with the problem, divided by the total area of the analyzed element (see Equation 1).

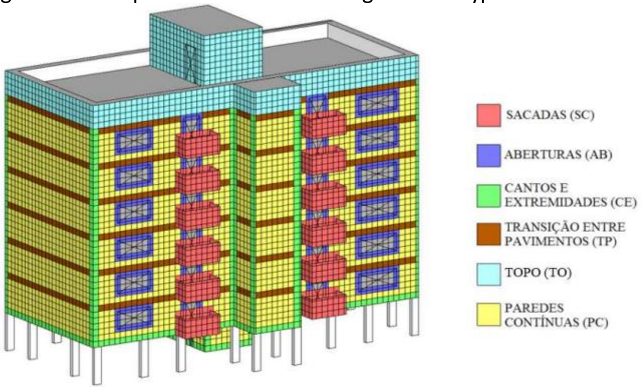
$$FD = \frac{\sum A_{d(n)}}{A_t} \quad \text{(Equation 1)}$$

Where:
$A_{d(n)}$= Area degraded by a pathological infestation n, in square meter (m²).
A_t = Total area of the element, in square meters (m²).

The quantification of the pathological manifestations was done through a mesh overlay, with dimensions of 0.50 m x 0.50 m (0.25 m²) on the facade plans, making it possible to account for the area of influence of the problem, which can often present irregular geometry, such as detachment or only one line, such as cracks. This dimension was defined in the study by Silva (2014) who tested several meshes and this was considered the most adequate, thus being replicated in other studies that propose to calculate the FD.

Based on the studies by Silva (2014), Souza (2016) and Santos (2018), the Damage Factor can also be analyzed in relation to the six regions into which the façade can be divided, namely: balconies (SC), characterized by being cantilevered; openings (AB), areas around the frames; corners and ends (CE), contours of façade planes; transition between floors (TP), areas between floors of the building; top (TO), the region above the top floor; and continuous walls (PC), flat areas that were not classified in any of the other regions. Figure 4 illustrates an example of the division of these regions.

Figure 4 - Example division of the six regions in a hypothetical building



Source: Santos (2018)

By dividing the facade into distinct regions, it becomes feasible to calculate the Region Damage Factor (FDr) using Equation 2, which helps in assessing the specific damage sustained by each region.

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$$FDr = \frac{\sum A_{d\,(r)}}{A_t} \quad \text{(Equation 2)}$$

Where:
$A_{d(r)}$= Degraded area of each region, in square meters (m²).
A_t = Total area of the element, in square meters (m²).

Santos (2018) emphasizes that simply using Equation 2 determines only the frequency of damage incidence, as it is affected by the size of each facade region. Since one region may have a significantly smaller area than another, this could lead to a tendency for larger regions to exhibit higher rates of degradation. To address this issue, a correction coefficient for regions (CCr) was proposed and has also been adopted in this study (see Equation 3).

$$CCr = \frac{A_{r\,(m)}}{A_{r(x)}} \quad \text{(Equation 3)}$$

Where:
$A_{r(m)}$= Area of the smallest region, in square meters (m²).
$A_{r(x)}$ = Area of the region under analysis, in square meters (m²).

Thus, Equation 4 represents the final form used to obtain the Corrected Region Damage Factor (FDrc).

$$FDrc = \frac{\sum A_{d\,(n)}}{A_t}\, x\, CCr \quad \text{(Equation 4)}$$

Where:
$A_{d(n)}$= Degraded area of each region, in square meters (m²).
A_t = Total area of the element, in square meters (m²).
CCr = Correction Coefficient of the region under analysis.

4 RESULTS

The central marking block, located at 310, Arnóbio Marques Street, Santo Amaro, Recife, is the first building visible from the guardhouse entrance. While there are no available records regarding the building's construction, it is estimated to have been built during the expansion that occurred in 1925. The block is constructed using ceramic brick masonry, with mortar coating painted yellow and covered with colonial tiles. It currently houses appointment scheduling and a palliative care centre. Inspections of the building were conducted on May 26, 2023, and June 2, 2023. To facilitate the identification of problems, the facades were named based on their orientation on the wind rose, with collateral points being selected due to the building's inclined position.

4.1 Southwest Facade

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The Southwest Facade serves as the main entrance of the building, facing the guardhouse and patient entrance, offering the initial view of the university hospital's main entrance. Although there are no official records of interventions in the health unit's buildings, information was obtained from the hospital's engineering team indicating that some blocks were repainted due to the visit of the new health secretary, a change resulting from the 2022 state elections. The block under study was one of those repainted, but it became evident that this intervention did not adhere to engineering best practices, as within a few months, pathological manifestations appeared.

Due to its significant horizontal dimension, the Southeast Facade Damage Map, shown in the following figure, was divided into three parts for better visualization, with cut lines indicated as 1-2 and 3-4.

Figure 5 - Damage Map of the Southeast Facade

Source: authors

On the Southwest Facade, the most commonly observed pathological manifestation was mold and mildew. Two sources of humidity that contribute to this issue are rain running down the facade and splashing on the baseboard, and pipes transporting wastewater from the building's air conditioning condensers. It was noted that the ends of these pipes either point directly towards the facade or leak at the connection with the destination pipe, creating consistently damp areas. This is evident from the accumulation of water on the walls and

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sidewalks, providing a favorable environment for microorganism growth. The porosity and roughness of mortar coatings also play a role in this problem, as they allow water absorption and retention, facilitating microorganism adhesion (OLIVEIRA JÚNIOR et al., 2021).

Two types of cracking were observed. One type occurs at the junction between the masonry of the continuous wall and the pavement slab, while the second type is attributed to reinforcement corrosion. Despite the building predominantly consisting of walls made of approximately 30 cm thick ceramic masonry, when using a pacometer, metal was detected along a crack with an opening of 0.45 mm. This indicates a pathological manifestation resulting from the expansion of the coating due to reinforcement corrosion in the structure.

4.2 Northwest Facade

The Northeast Facade, located on the left side of the building facing the Faculty of Medical Sciences of the University of Pernambuco, does not have any access doors. Pathological manifestations similar to those found on the Southwest Facade were identified here as well. Particularly noteworthy is the issue of inadequate disposal of wastewater from refrigeration equipment, which leads to water puddles on the sidewalk, causing inconvenience to hospital users. Additionally, paint peeling and cracking were observed, albeit to a lesser extent. The cracking is attributed to the building's proximity to another structure, resulting in deformations caused by thermal variations and the movement of different materials.

The Damage Map below provides a summary of the pathological manifestations identified on this facade.

Figure 6 - Damage Map of the Northwest Facade

Source: authors

4.3 Northeast Facade

The northeast facade is the rear facade of the building, where access is only permitted for employees. It was not included in a painting renovation to be presented to the new state Government, probably because it was at the back of the building, an area with less circulation. Pathological manifestations were observed at a more advanced stage on this facade.

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Similar to the southeast facade, the northeast facade damage map was divided into three parts in order to provide better visualization.

Figure 7- Damage Map of the Northeast Facade

Source: authors

There is a presence of large amounts of mold, parasitic vegetation, and pigeon droppings on this facade, in addition to the lack of maintenance. It is worth mentioning that the building is a health unit, and the presence of this biological material can directly interfere with the health of its users, both patients and employees. In the case of parasitic vegetation, the roots grow inside the coating, generating tensions that impair adhesion, in addition to the constant presence of a source of humidity from air conditioning, which causes the segregation of the layers that make up the coating.

Peeling paint, peeling of the coating, and cracks along the coating were also observed. After analyzing these manifestations, it is possible to indicate that there are large amounts of paint accumulated on the facade and that the substrate is in a powdery state,

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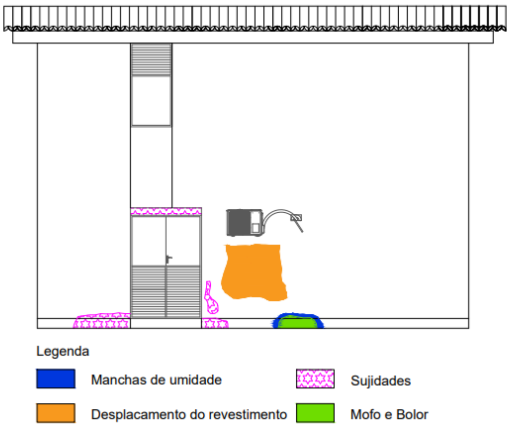
indicating that during the intervention actions there was no adequate preparation of the surface, such as removing non-adherent material, before receiving a new coating.

4.4 Southeast Facade

The southeast facade is the right-side facade of the building, facing the main board building and serving as the access to a collection point. This facade exhibits dirt, mold, mildew, and peeling of the coating, which can also be attributed to the constant presence of humidity generated by rain and a refrigeration device. Above the access door, there is a canopy which, being the most prominent element of the facade, receives direct environmental exposure along its length, resulting in an accumulation of dirt. Figure 8 shows the Damage Map of the facade, summarizing the pathological manifestations identified.

Figure 8 - Damage Map of the Southeast Facade



Source: authors

4.5 Calculation of damage factors corrected by regions.

To conduct a quantitative analysis of the pathological manifestations observed on the facades, the study proposed calculating the Corrected Regions Damage Factor (FDrc) to quantify the presence of issues. Each of the six regions, when present, was delimited on the Damage Map as a 0.25 m² overlapping mesh starting from the extreme lower left corner. The number of squares covering the pathological manifestation was counted and the calculations were grouped by manifestation. Regions where no pathological manifestations were identified were excluded due to the zero result.

The Southwest and Northeast Facades presented the highest values of FDrc due to the manifestation of mold and mildew in the corners and ends, as shown in Table 1. This result may be linked to the fact that the lower region of the facade is affected by splashes from rain and residual water from refrigeration devices, resulting in areas with constant humidity. This, combined with a lack of maintenance and constant solar irradiation creates a favorable environment for biodegradation.

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Table 1 - FDrc of the facades of the central marking block for mold and mildew issues.

Mold and mildew						
			Southwest Facade			
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
CE	28.75	331.64	7.00	17.50	0.40	0.0347
PC	18.50	331.64	7.00	185.94	0.04	0.0021
			Northwest Facade			
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
AB	0.25	37.35	0.64	9.97	0.06	0.0004
CE	2.25	37.35	0.64	4.04	0.16	0.0095
PC	1.00	37.35	0.64	20.20	0.03	0.0008
			Northeast Facade			
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
AB	9.00	294.26	6.96	71.99	0.10	0.0030
CE	24.25	294.26	6.96	15.07	0.46	0.0381
TP	0.50	294.26	6.96	6.96	1.00	0.0017
TO	12.50	294.26	6.96	16.17	0.43	0.0183
PC	32.75	294.26	6.96	184.07	0.04	0.0042
			Southeast facade			
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
CE	0.75	49.03	0.22	4.00	0.06	0.0008

Source: authors.

On the Southeast Facade, the pathological manifestation with the highest FDrc was dirt on the balcony (Table 2), with 100% presence in this region. This issue may be associated with the architectural design. The cantilevered element is the most prominent on the facade, thus being the first to endure the effects of the environment, such as wind and rain. When combined with the lack of periodic cleaning, this promotes the accumulation of dirt, a concern also noted by E. Bauer *et al.* (2015).

Table 2 - FDrc of the facades of the central marking block for dirt issues

Dirt						
			Southwest Facade			
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
AB	4.50	331.64	7.00	101.88	0.07	0.0009
CE	4.75	331.64	7.00	17.50	0.40	0.0057
PC	41.25	331.64	7.00	185.94	0.04	0.0047
			Northwest Facade			
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
CE	0.25	37.35	0.64	4.04	0.16	0.001
PC	1.00	37.35	0.64	20.20	0.03	0.001
			Northeast Facade			
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
AB	23.00	294.26	6.96	71.99	0.10	0.0076
CE	0.75	294.26	6.96	15.07	0.46	0.0012
PC	6.25	294.26	6.96	184.07	0.04	0.0008
			Southeast facade			
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
SC	1.00	49.03	0.22	0.22	1.00	0.0204
CE	1.25	49.03	0.22	4.00	0.06	0.0014
PC	1.75	49.03	0.22	39.45	0.01	0.0002

Source: authors.

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Peeling paint (Table 3), cracks (Table 4) and peeling coating (Table 5) were the problems with the lowest damage factors. Among them, the highest FDrc value for peeling was presented by the region of openings on the Northeast Facade and for cracks in the region of corners and ends of the Northwest Facade. Also on this last facade, the most significant coating peeling occurred in the region of continuous naked walls, which may result from the loss of adhesion due to the presence of humidity and incorrect preparation of the substrate of this area, which has the largest size compared to the others.

Table 3 - FDrc of the facades of the central marking block for the problem of paint peeling

Paint peeling						
Southwest Facade						
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
AB	1.00	331.64	7.00	101.88	0.07	0.0002
TO	0.50	331.64	7.00	19.32	0.36	0.0005
PC	1.00	331.64	7.00	185.94	0.04	0.0001
Northwest Facade						
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
PC	150	37.35	0.64	20.20	0.03	0.0013
Northeast Facade						
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
AB	6.00	294.26	6.96	71.99	0.10	0.0020
CE	0.50	294.26	6.96	15.07	0.46	0.0008
TP	0.50	294.26	6.96	6.96	1.00	0.0017
PC	13.00	294.26	6.96	184.07	0.04	0.0017

Source: authors.

Table 4 - FDrc of the facades of the central marking block for cracking issues

Cracks						
Southwest Facade						
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
AB	2.25	331.64	7.00	101.88	0.07	0.0005
TO	2.25	331.64	7.00	19.32	0.36	0.0025
PC	2.75	331.64	7.00	185.94	0.04	0.0003
Northwest Facade						
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
CE	1.50	37.35	0.64	4.04	0.16	0.0064
PC	0.75	37.35	0.64	20.20	0.03	0.0006
Northeast Facade						
Region	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
PC	2.00	294.26	6.96	184.07	0.04	0.0003

Source: authors.

Table 5 - FDrc of the facades of the central marking block for the problem of coating peeling

Coating peeling						
Southwest Facade						
Região	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
CE	0.50	331.64	7.00	17.50	0.40	0.0006
PC	0.50	331.64	7.00	185.94	0.04	0.0001
Northwest Facade						
Região	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
PC	1.50	37.35	0.64	20.20	0.03	0.0013
Northeast Facade						
Região	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
PC	1.50	294.26	6.96	184.07	0.04	0.0002
Southeast facade						

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Região	Ad (n)	At	Ar (m)	Ar (x)	CCr	FDrc
PC	2.50	49.03	0.22	39.45	0.01	0.0003

Source: authors.

In general, the floor transition and top regions showed the least significant manifestations. This is in contrast to the findings of Bauer, Souza, and Mota (2021) who in their study on the Intensity and scope of deterioration in mortar facades in Brasília, the capital of Brazil, identified that the top region was the area with the highest incidence of degradation particularly for stains in all analyzed orientations. This difference in results regarding this region between studies can be attributed to the facades' configuration which influences degradation, as highlighted by Souza, Piazzarollo, and Bauer (2019). In the Block, the top is represented by a slab covered with a roof made of colonial tiles extending from the end of the structure, without the existence of a platband, which makes the region protected and less exposed to agents of degradation.

5 CONCLUSIONS

It is crucial to conduct effective maintenance for the conservation of a heritage site, which is subjected to the direct impact of aggressive environmental factors, in order to prevent the progression of issues that could affect the building's durability.

The Damage Map technique is not yet widely utilized in the construction field despite its value in assisting decision-making for maintenance plans. This may be attributed to the lack of regulations and professionals knowledgeable about the technique, underscoring the importance of conducting studies incorporating its application to advance scientific knowledge in various sittings, such as hospitals.

At HUOC, the pathological manifestations observed during inspections follow a specific pattern along the facades with mold, mildew, and dirt being the most prevalent. The combination of insufficient preventive maintenance, inadequate corrective measures, and interventions without addressing the root causes of the issues allows these manifestations to develop. Additionally, the direct impact of pigeon droppings and water from air conditioning drains exacerbates the situation.

By calculating Damage Factors, it was possible to evaluate degradation in relation to different regions of the facade, enabling the identification of potential factors influencing damage to the elements. For instance, there was a higher incidence of mold and mildew in corners and ends, as well as dirt accumulation on balconies.

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