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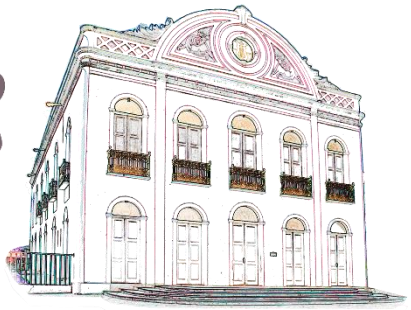

Damage maps of façades of a public university

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Abstract: For a building to perform well during its useful life, it is essential that exist an adequate control during the design and execution phases of the structure, as well as periodic maintenance, over the years, after its construction. The Polytechnic School of Pernambuco (POLI) was founded 110 years ago and consists of several blocks of buildings that were built over the years, therefore, the institution is susceptible to exposure to building defects due to the useful life of the blocks, to the various materials in which they were built and the lack of periodic maintenance. The objective of this research was to carry out the identification of the building defects present on the façades of Block D of POLI and to elaborate their respective damage maps. As a methodology, a case study was carried out, where visual inspections were made through photographic records, then, the elaboration of damage maps through AutoCAD software. After inspection of the façades, the high presence of building defects was identified, especially on the front façade, among which the main ones were peeling paint and dirt. The damage maps made possible to gather the defects present in a relatively precise and easy to understand way, being a fundamental document to help the necessary maintenance of Block D plan, to guarantee its conservation.

Keywords: building defects; damage maps; façade inspections.

1. Introduction

The concern in the pursuit of quality and performance of buildings has become increasingly noticeable, leading to the need to consider the concepts of durability and service life in their projects (ROCHA, 2017). For a building to perform well during its useful life, it is essential that there is adequate control during the design and execution phases of the structure, as well as periodic maintenance, over the years, after its construction.

In addition, in civil construction, the emergence of problems in the building at an early stage has become increasingly common, leading to the need to carry out costly interventions (SILVA *et al.*, 2018). These problems are considered pathological if they compromise any construction requirements, such as their functional capacity (ROCHA, 2017).

On building façades, for example, the presence of pathological problems is very common due to the great exposure of degrading agents. Carrying out maintenance for the conservation of the façades is essential, since they have the function of protecting and preventing the passage of external agents such as water, solar radiation and wind, into the interior of the building (CAVALCANTI; MONTEIRO, 2021; SANTOS, 2018).

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In addition, they have an aesthetic function for the building, an important aspect for buildings of public and historical heritage due to the need for preservation, since, according to Medeiros and Surya (2009), heritage is like a collection of historical events of a given society.

In view of the need for conservation of a building, one of the essential documents that has been used for building inspections is the damage map (ROCHA *et al.,* 2018; SILVA; CUPERSCHMID, 2022). Through an analysis of the damage map, it is possible to draw up restoration and maintenance plans, with the aim of carrying out actions that seek to conserve and prolong the useful life of a building (IPHAN, 2005).

The Polytechnic School of Pernambuco (POLI), located in the city of Recife, is a public educational institution linked to the University of Pernambuco (UPE), and plays a fundamental role in society as an institution that trains professionals in different types of engineering. The Polytechnic School was founded 110 years ago and is made up of several blocks of buildings that were built over the years. Therefore, the institution is susceptible to exposure to building defects due to the useful life of the blocks, the different materials in which they were built and the lack of periodic maintenance.

Thus, the objective of the present work is to carry out the identification of the building defects present on the façades of Block D of POLI and to elaborate a map of damages, with the intention of contributing in the planning of maintenance and conservation of the façades of the structure.

2. Theoretical reference

For a better understanding of the results of the case study, in this topic, the most important concepts regarding building defects and damage map will be addressed.

2.1 Building defects

Pathology of structures, or pathology of constructions, is a field in civil engineering that deals with the study of incident anomalies in the structure as a whole, through the identification of their origins and mechanisms of occurrence, and these anomalies are called building defects (BOLINA; TUTIKIAN; HELENE, 2019). These defects are those deficiencies that are observed in some elements and can be an indicator of a problem in the structure, such as: cracks, breaks, displacements and deformations (BOLINA; TUTIKIAN; HELENE, 2019).

The degradation of a structure, due to the incidence of building defects, can be caused by several physical, chemical and biological agents that are found in nature or in the materials used for its construction. The diagnosis of these damages in a building is necessary to carry out maintenance in order to guarantee the conservation of its useful life (ROCHA *et al.*, 2018). Among the main defects in buildings, the following stands out:

2.1.1 Fissures and cracks

Cracks are usually one of the first symptoms presented by concrete structures, they are characterized by being openings on the surface of a structural element, causing exposure to aggressive agents (NASCIMENTO; FONTES, 2021).

Cracks also have the same definition, however, they differ by the size of their opening, the fissures has up to 0.5 mm and the crack has up to 3 mm of opening (THOMAZ, 2020). Some mechanisms that can cause its formation are: movements caused by temperature and humidity variations, overloading, differentiated settlement of foundations, retraction of products based on hydraulic binders and chemical alterations of construction materials (THOMAZ, 2020).

2.1.2 Breakdown or detachment of concrete

The disaggregation of concrete in structures can be understood as the physical separation in forms of concrete plate and loss of adhesion with the aggregates and, as a consequence, it may lose resistance to efforts (BERTI; SILVA JR.; AKASAKI, 2019; SOUZA; RIPPER, 1998). Some factors that cause concrete disaggregation are: cracks, formwork movement, concrete calcination and biological attacks (SOUZA; RIPPER, 1998).

2.1.3 Corrosion

Corrosion is characterized as the change in the properties of the metal (steel) after a physical-chemical interaction with the environment (ISO, 2015). When reinforcement has insufficient coverings or poorly compacted concrete, it will be susceptible to the action of external agents such as water and air, leading to its corrosion (THOMAZ, 2020). Due to this phenomenon, there is a loss of the film that protects the steel bar and the consequent loss of section (NASCIMENTO; FONTES, 2021).

2.1.4 Detachment of paint

Paint detachment can be defined as the detachment of the paint film from the substrate (wall) due to loss of adhesion (CHAI *et al*., 2011; SANTOS, 2018). This anomaly arises due to factors such as: the performance of degradation agents, the effect of other existing problems in the coating and the age of the materials, in addition to errors in the execution process (CHAI *et al*., 2011; SANTOS, 2018).

2.1.5 Dirt

Presence of particles on the cladding surface, caused by atmospheric pollution, influence of cladding materials or lack of protection on the façades in regions where, for example, it is susceptible to the action of rainwater and water from air-conditioning or sewage pipes. hydrosanitary installations (PACHECO; VIEIRA, 2017; PERLEBERG *et al*., 2019). It is a type of manifestation that does not cause severe risks to the structure of the building, only undesirable aesthetic effects (PERLEBERG *et al*., 2019).

2.1.6 Mold

Proliferation of microorganisms (fungi) due to the presence of humidity, lack of exposure to the sun, lack of ventilation or high temperatures. The appearance of dark stains occurs and can lead to deterioration of the coating (CHAVES, 2009; GONZAGA *et al*., 2017).

2.1.7 Vegetation

It occurs due to the presence of humidity in the region, due to transposition caused by winds, use of materials that do not have waterproofing capacity or lack of maintenance in the plumbing present on the façades (PACHECO; VIEIRA, 2019; TERRA, 2001).

2.2 Damage maps

The damage map corresponds to a graphical representation of damage present in a building, such as cracks, corrosion and mortar detachment, making it possible to identify the causative agents and assess the state of conservation of the structure (IPHAN, 2005).

According to Tinoco (2009), the damage map is a graphic-photographic document that meticulously illustrates the pathological manifestations, so that it summarizes the investigations carried out on the condition of the building. Therefore, it can be used as a recording and monitoring tool to control the degradation process of the structure, in addition to assisting in the preparation of conservation and restoration projects. (MOURA JR.; PÓVOAS, 2022).

3 Methodology

To carry out the research, the methodology used was the elaboration of a case study that consisted of the analysis of the façades of one of the POLI buildings and, for this, Block D was chosen. According to the concepts of Severino (2014), the research is classified as qualitative, with exploratory and explanatory objectives.

At first, a bibliographic review was carried out in some databases: Google Scholar, Portal de Periódicos CAPES, Scielo and Scopus. Articles published in journals, articles published in congresses, dissertations and books were searched to gather information on the subject for the elaboration of the theoretical framework,

presented in the previous topic, which brings together the main concepts addressed during the research and, then, carry out the case study.

To prepare the study, a 5-step script was followed, as shown in Figure 1, which began with visits to Block D to survey the building's measurements, using a laser measuring tape and a common measuring tape. With the measurements, drawings of the four façades were made in AutoCAD software and then inspection visits were made in order to assess the conditions of the structure and identify building defects on the façades, which were recorded using mobile phone photos. After that, the damage maps was prepared in AutoCAD and the results found were analyzed.

Figure 1 – Script for the case study

4 Results and discussions

Block D was inaugurated in 2009, comprising the advanced civil construction laboratory and study room of the PEC (Postgraduate Program in Civil Engineering at POLI). The inspection of all the facades of this building was carried out on September 21, 2022, during a sunny afternoon.

4.1 Building characterization

As shown in Figure 2, Block D is a mixed building, consisting of ceramic block masonry in the lower region and cement block in the upper region where horizontal rectangular openings (cobogós) are located. Its roof is composed of a W-profile fibrocement tile supported by horizontal metal truss supports and metal pillars, which are also part of the block's structure.

Figure 2 – Block D

4.2 Front façade (north façade)

The front facade gives access to the advanced civil construction laboratory, as shown in Figure 2, and the study room, as shown in Figure 3. In addition, on the right side of the façade there is a door at the back of the building that gives access to a laboratory of one of the POLI extension teams, as shown in Figure 4.

Figure 3 – Entrance to the PEC study room

Figure 4 – Entrance to the laboratory

On the ramps that provide access to the rooms, the presence of dirt, cracks, and fissures on their sides were observed, as shown in Figures 5 and 6. These mapped fissures may have been caused by hygroscopic changes in the material used for the ramp coating during the execution process. As for dirt, its appearance may have been caused by the absence of rainwater drainage mechanisms in the building and institution, which leads to flooding on days of heavy rain and, consequently, darkening in the lower regions of the facades.

Figure 5 – Fissures on ramp

Figure 6 – Dirt on the ramp

In the lower part of the façade, the presence of paint detachment from one or more layers of paint was identified, in almost its entire length, leaving the mortar coating exposed and susceptible to aggressive agents, in addition to fissures indicating future detachments. It is possible that the façade was painted more than once and the substrate was not properly prepared for the application of the new paint, resulting in these problems that cause unpleasant aesthetics for the building, as can be seen in Figure 7.

Figure 7 – Paint detachments

The building has a tiled roof, which is made up of horizontal supporting metal parts and metal pillars, which are also part of the structure of the façades. In the vertical pieces, the presence of corrosion and vegetation was identified, as in Figures 8 and 9, indicating the presence of water in this region. Corrosion could have been caused due to lack of cover or some type of adequate protection on the pillars, in Figures 8 and 9 it can be seen that the only protection would be the paint that was used to paint the entire building and is highlighting on the sides of the pillars. pillars, making the region susceptible to the entry of rainwater.

Figure 8 – Corrosion and vegetation

Figure 9 - Corrosion and vegetation on the column

In all doors and windows, the presence of fissures was identified, which can be seen in Figure 10. Some of them are at a 45-degree angle, indicating the absence of lintels and sills, while others may have been caused by thermal expansion of the door and window materials, as this façade receives a lot of sunlight as it faces west.

Figure 10 – Fissures on doors and windows

In the back part of the building, where the extension group's laboratory is located, in addition to the 45° fissures in the window, the presence of dirt and vegetation was also identified, which can be seen in Figure 11, indicating the presence of water that can be the condensers that are to the side, on the right side façade.

Figure 11 – Dirt and vegetation

For a better visualization of the location of the aforementioned problems, a damage map of the façade was prepared, which can be seen in Figure 12. On the map, it is possible to identify the predominance of orange,

purple and red colors that represent paint detachment, dirt and fissures, respectively. The façade has a large presence of defects, eight different types, due to the lack of conservation, bringing an undesirable appearance to the building, mainly the front façade.

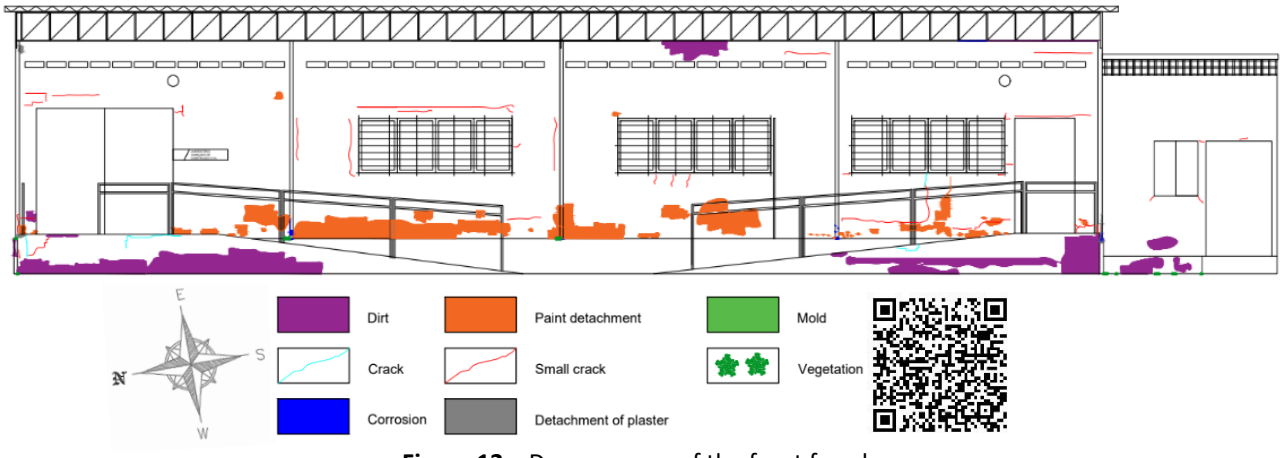

Figure 12 – Damage map of the front façade

4.3 Right side façade (west façade)

On the right side façade, as shown in Figure 13, it is possible to see only the part of the concrete pillar as, right after, there is a small entrance that is also part of Block D. During the inspection, it was not possible to remove the objects present in front of the façade for a better photo, however, this did not hinder the identification of the present problems.

Figure 13 – Right side façade

In the supporting structures of the roof, it was possible to identify the presence of corrosion, as shown in Figure 14. This problem may have been caused due to contact with rainwater or water from the condensers located in the adjacent building, Block C. In addition, the absence of an anti-corrosive treatment to protect the steel components can accelerate the corrosive process.

The presence of corrosion was also identified at the end of the metallic pillar that is part of the support of the tile, as shown in Figure 15, the corrosion may have started due to the peeling of the plaster that kept it protected.

Figure 14 – Pieces with corrosion

Figure 15 – Pillar of the right side façade

In Figure 15, it is possible to see the presence of a crack in the plaster, which shows that the facade is still susceptible to further detachment in that region. In addition, there are several fissures and paint detachment, which are constant problems throughout this facade, as shown in Figure 16.

The possible causes for these damages may be similar to those of the front facade, such as lack of preparation of the substrate to receive the new paint, in addition to the presence of water from the condensers generating moisture. It is worth noting that the lack of substrate or plaster can contribute to the appearance of the courses of the masonry, making them susceptible to degrading external agents.

Figure 16 – Fissures and paint detachment

On this façade, there are two air conditioning condensers and the presence of a fissure above each one was noted. The possible cause would be due to the closure of some previously existing openings on all façades, Figure 17 shows the presence of small openings and just below the closing marks of others, which may result in later cracks.

Figure 17 – Marks on the façade

In the lower part of the façade, below the condensers, the presence of mold stains was also identified, possibly due to the humidity caused by the equipment. In the area of the ramp there is also the presence of dirt and peeling plaster, which are represented in the damage map in Figure 18.

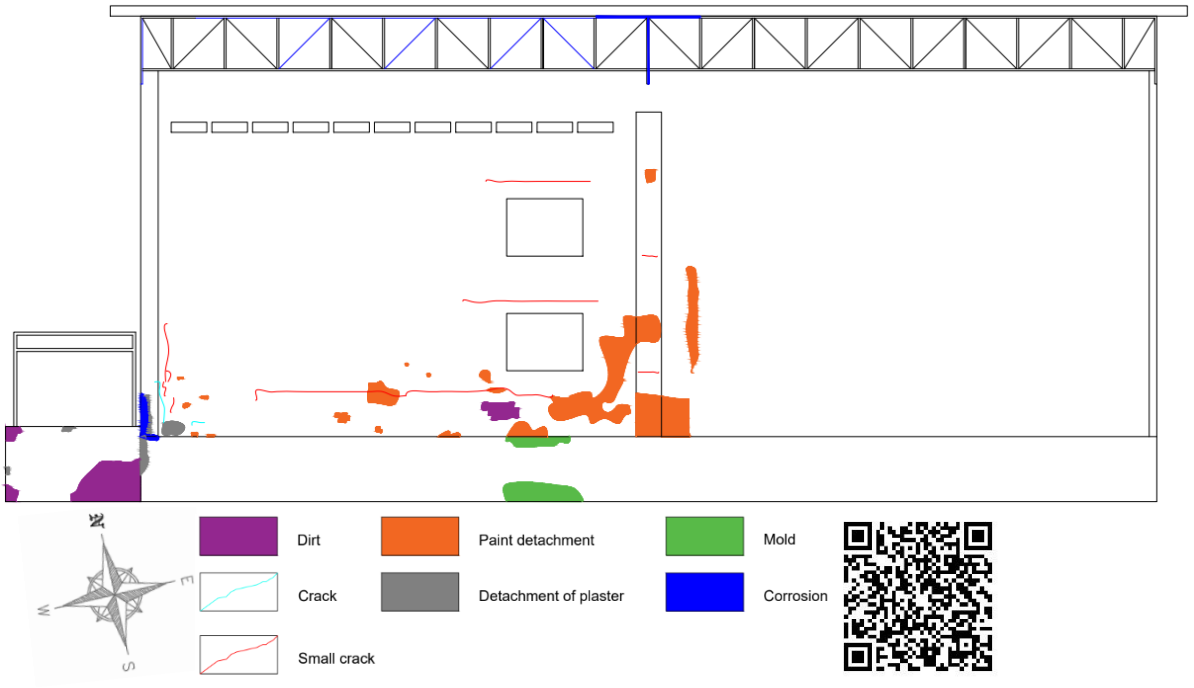

Figure 18 – Damage map of the right side façade

As previously mentioned, from the pillar it is not possible to visualize the façade, therefore, the map is blank in the region on the right. As for the left region, there are many types of anomalies, there is a lower presence of dirt and a greater presence of plaster detachment when compared to the front façade. Besides that, in addition to the pillar, corrosion is also found on the metal parts of the tile.

4.4 Left side façade (east façade)

The left side façade, as shown in Figure 19, is in better condition than the other façades.

Figure 19 – Left side façade

During the inspection, it was possible to find only small detachments of paint, as in Figure 20, and dirt on the lower part of the façade and on the ramp, in addition to a crack and the presence of a small vegetation, as shown in Figure 21. The crack could have originated due to the meeting of the pillar with the wall, both of different materials.

Figure 20 – Paint detachments

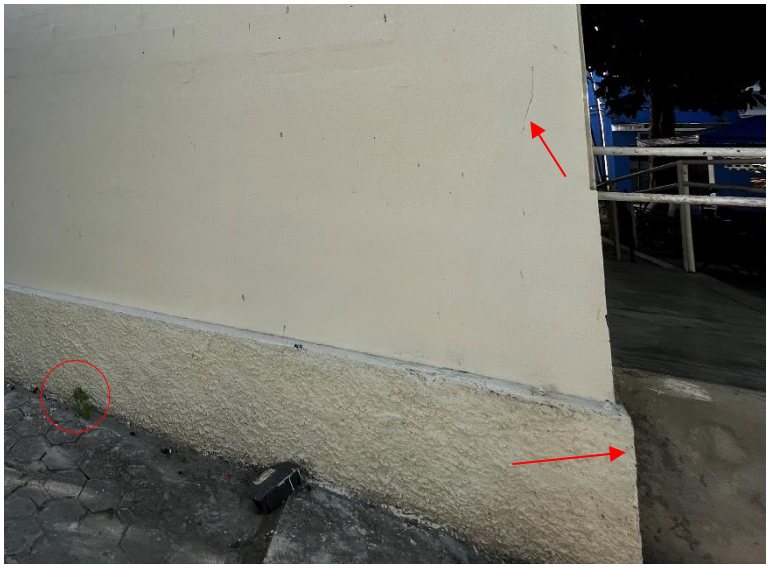

Figure 21 – Building defects of left side façade

It was also identified the presence of dirt in the upper left part of the façade and detachment of plaster at the right end of the ramp. The detachment of plaster in the ramp regions may be due to the use of different materials for its construction and the preparation of the floor (such as the type of mortar used) or due to thermal expansion, leading to disaggregation of materials and, consequently, detachment.

Figure 22 shows the façade damage map, gathering the location of the problems found and their respective nomenclature. In it, it is possible to see the predominance of dirt in relation to the other manifestations and it is only found in the lower region, also only a crack and no fissure was found.

The façade is in a better state of conservation than the others, which may indicate that it is less susceptible to degradation mechanisms or that it has received some type of maintenance, such as cleaning and repainting.

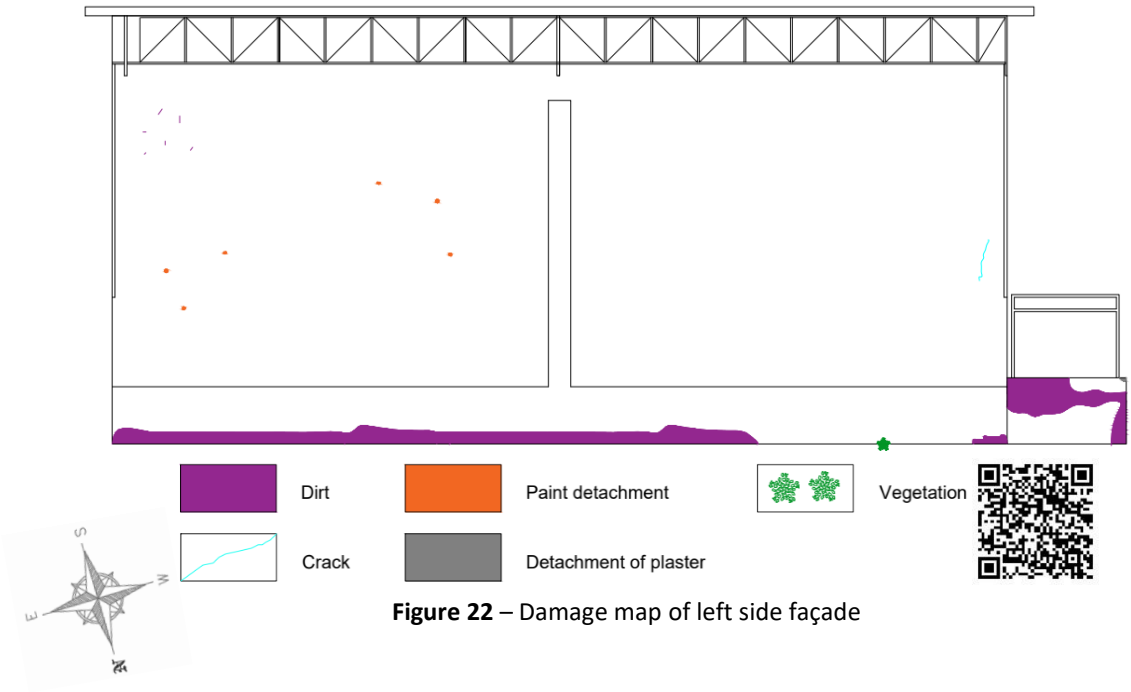

Figure 22 – Damage map of left side façade

4.5 Posterior façade (south façade)

In the posterior facade, only photographic records of pathological manifestations were made, as access is through a narrow corridor to another building block. In this facade, there are three air conditioning condensers with small openings made in the facade for the passage of electrical conduits and plumbing. Due to the presence of moisture, dirt and mold stains were found, as shown in Figures 23 and 24.

Figure 23 – Dirt and mildew stains

Figure 24 – Mold

Along the length of the façade, more mold and dirt patches were seen, as well as some peeling plaster. In some parts of the roof of the building, which can be seen in Figure 25, the presence of corrosion that may have arisen due to contact with rainwater was also identified.

Figure 25 – Pieces with corrosion

The damage map in Figure 26 shows all the façade details, however, it is worth noting that on the left part of the façade, where small openings are located, there is no damage drawn on the map because there is an entrance to another block, which is not possible to analyze the region.

The façade also shows little incidence of defects, as well as the left side, with corrosion, mold and dirt more present, in relation to the others. A crack and a fissure were identified, there is also the presence of corrosion on the supporting parts of the tile, as on the right side façade.

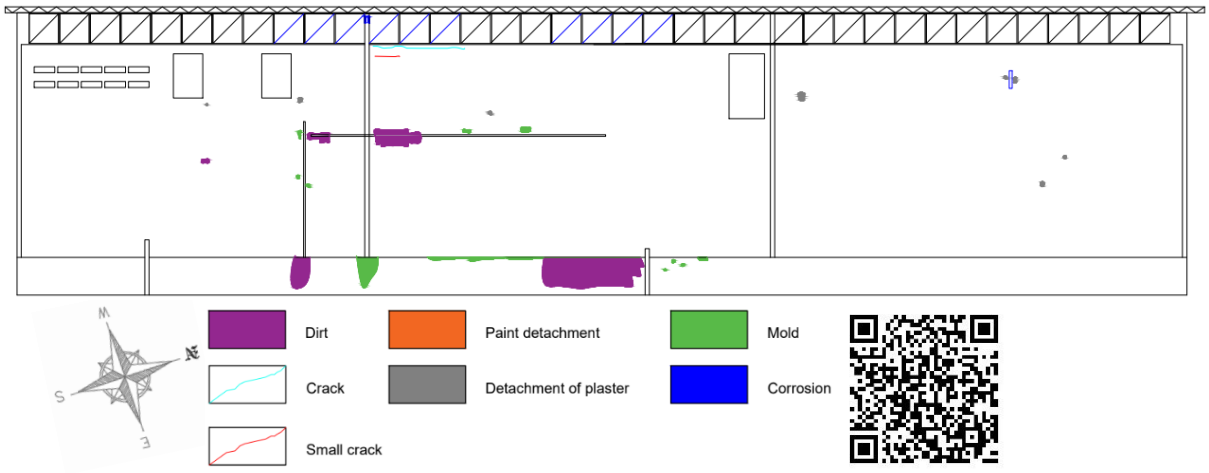

Figure 26 – Damage map of the posterior façade

5 Final considerations

After inspection of the façades, the high presence of building defects was identified, especially on the front façade. Detachment of paint and dirt are the most common problems and cause an unpleasant aesthetic for the building, in addition, defects such as: corrosion, detachment of plaster, vegetation, mold, cracks and fissures were also found, evidencing the lack of periodic maintenance.

The damage maps made it possible to gather the defects present in a relatively precise and easy to understand way, in addition to showing their respective locations. With them, it is possible to receive assistance to analyze the physical and aesthetic state of the structure and to prepare plans for possible restorations and repairs in the building.

Therefore, it is expected that the maps can assist in the maintenance planning of Block D to guarantee its conservation, due to its importance as a public asset, in addition, in the future it may suffer structural damage

that affect its performance and useful life, mainly in the regions of metallic pillars that are in the process of corrosion.

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