v. 3, n. 31, 2023

Journal of
Engineering
Research

CASE STUDY: ANALYSIS OF PATHOLOGICAL MANIFESTATIONS FOUND IN THE GARAGE AREA OF A BUILDING IN ARMED CONCRETE LOCATED IN THE CITY OF RECIFE-PE

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Abstract: The practice of building houses by human beings is very old and over time there has been an accelerated growth of construction techniques, which began to cause the appearance of pathological manifestations arising from various factors (poor quality materials, execution errors, etc.). Due to this, the area of Pathologies in Buildings was created, which is focused on the study and analysis of these manifestations. Therefore, the present work was developed with the intention of analyzing the pathological manifestations found in a residential building located in the city of Recife-PE. For the development of this research, a very detailed bibliographic review was initially carried out, followed by the methodology used. The chosen method was the case study, widely used in research related to pathological manifestations today. For data collection, an inspection was carried out in the building's garage through a photographic survey of the main pathologies found. After this collection, data analysis was carried out, ending with the presentation of the identified pathologies, as well as their probable causes of occurrence and possible solutions. It was concluded that several pathologies can be avoided or even discovered in advance if more preventive maintenance is carried out in buildings, something that is rarely done today.
Keywords*:* Pathological Manifestations; Prevention; Correction; Reinforced Concrete.

INTRODUCTION

The practice of construction is an activity developed by man since the beginning of civilizations and, due to this, construction methods have been passed and improved from generation to generation. According to Ferreira [3], over the years, man sought to organize himself into groups in order to better organize himself in the space that surrounded him, which led to the beginning of a period of construction on a large scale. However, with the Industrial Revolution, some modifications were made in the construction processes and new materials were introduced, such as cast iron, steel and, finally, concrete. Reinforced concrete only came to be actually used in Brazil at the beginning of the 20th century, with intensified use from the 1950s onwards.

With the fast-paced development of civil construction, in order to meet a high demand for buildings that were work, industrial or residential, there was a great scientific and technological leap with regard to the use of reinforced concrete, also greatly driven by modernization itself. of society (AMBRÓSIO [1]).

This way, due to this sudden leap in construction techniques, many structures end up developing pathologies caused by the misuse of materials at the time of their construction, constructive vices from the past, design errors, involuntary human failures and, in most cases, aging. of the building due to the actions of the environment.

Therefore, it was necessary to create an area in Engineering dedicated to the study of these pathological manifestations, thus giving rise to the branch of Structural Pathologies. According to Arivabene [2], this field "is concerned with the study of the origins, forms of manifestation, consequences and mechanisms for the occurrence of failures and the systems of degradation of structures."

In this context, one can see the importance of studying and correcting the pathological manifestations present in any type of building today. These pathologies directly interfere with the useful life of the building, affecting from areas that are simpler to be corrected, such as coatings, to more complicated areas of vital importance for the support of the building, such as reinforced concrete structures.

Based on this information, this work seeks to analyze the main causes and types of pathological manifestations found in

buildings today, especially in the object of study in question, in addition to proposing solutions for the pathological problems found in the case study, based on the information found in the adopted bibliography and in the knowledge acquired in the academic and professional life of the author of this study.

LITERATURE REVIEW

CONCRETE PATHOLOGIES

According to Isaia [4], the term pathology is used in Civil Engineering when there is loss or decline in the performance of components of the structure of a building.

Thus, pathological manifestations must be evaluated based on their origins, causes, ways in which they manifest and possible means of prevention and recovery. After analysis, if any impairment of the characteristics of the construction is identified, be it mechanical, functional, or even aesthetic, this anomaly must be considered a pathological manifestation and must be treated as soon as possible (FERREIRA [3]).

The first step to identify the cause of a pathological manifestation is to discover which agents are causing the deficiency found in the building. According to Isaia [4] some causes that may contribute to the occurrence of pathological manifestations are: mechanical stress, the characteristics of the materials that make up concrete, the exposure conditions of the building, the thickness of the covering, among others.

According to Arivabene [2] several studies prove that a high percentage of pathological problems originate in the planning and design phases of buildings. These types of failures are quite critical for constructions and are considered even more serious than failures related to construction methods and the quality of materials. This is due to the low investment in more detailed projects, both by public and private authorities, which ends up leading to last-minute adjustments during project execution and, consequently, to more serious pathologies in the future, which can be either functional and structural character.

Still according to Arivabene [2], assuming that the design stages of a project have been respected correctly and executed with adequate quality, even so concrete structures may still suffer from pathological manifestations caused by the misuse of the building or the lack of a proper maintenance program. Many of the pathological problems linked to the absence of preventive maintenance or even inadequate maintenance of the enterprise, have their origin linked to economic problems (such as lack of adequate investment for possible maintenance) and technical lack of knowledge on the part of the user.

The lack of maintenance by users after delivery of the building is also a fundamental factor for the emergence of pathologies in constructions, since after receiving the property, the user becomes responsible for the care and correct use of the building, in addition to being responsible for carrying out periodic maintenance throughout the enterprise.

Therefore, the analysis of these pathologies is fundamental to identify the origin and agents that cause such manifestations, as well as the consequences that these pathologies bring to the building itself. Thus, in Table 1 below, Machado *apud* Arivabene [2] reports the main pathological manifestations, in ascending order of statistical occurrence:

Pathological Manifestations	Occurrence (Percentage)
Deterioration and chemical degradation of construction	7%
Excessive deformations (arrows and rotations)	10%
Segregation of the component materials of concrete	20%
Corrosion of reinforced concrete reinforcements	20%
Cracks and active or passive cracks in reinforced concrete parts	21%
Stains on the surface of reinforced concrete	22%

Table 1 - Occurrence of pathological manifestations [2]

I. FISSURES, CRACKS AND CRACKS

According to Vitório [10], cracks are discontinuities that occur in concrete due to its low tensile strength. This type of pathology is very common in buildings and depending on their degree of openness, it can interfere with the aesthetics, durability and even the characteristics of the structure of the enterprise.

According to Souza and Murta [9] it is necessary to accurately define the classification of the crack in relation to its origin, its dimensions and, above all, its severity for the structure. From this definition, it is possible to identify the most appropriate treatment for the situation, as well as define the techniques and materials that must be used for this repair.

According to Lottermann [5], cracks are more pronounced and deeper openings in concrete. The main factor to differentiate a crack from a crack is the "separation between the parts", that is, the material in which a crack occurs is divided in two.

Because they are very similar to each other, cracks and fissures are very difficult to distinguish, thus requiring specialized equipment and professionals to carry out this differentiation process. In addition, cracks are considered more dangerous than cracks because they cause the element to rupture, which can affect the safety of the building structure.

Still according to Lottermann [5], cracks have the same characteristics as cracks in relation to separating the material into two parts, however cracks are considered more serious pathologies because they are larger, deeper and more pronounced openings when related to cracks. They are easily identifiable in buildings due to the large amplitude left by their openings in the affected element.

An opening to be considered a crack must have an amplitude of around 5.0 mm, in addition to allowing the passage of water, wind and even light through the environments. They require immediate attention and must be closed as soon as possible after identification. However, before closing the cracks, it is necessary to identify the reason why the crack occurred in the first place, in order to repair the original problem and prevent the pathology from reappearing in the future.

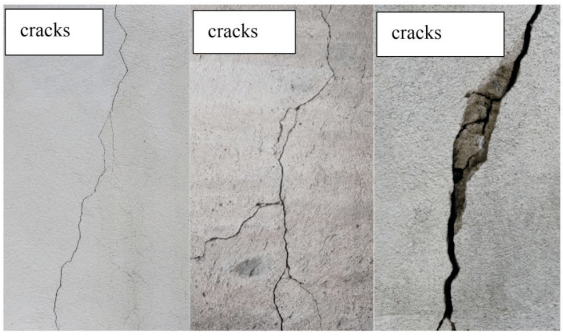

Figure 1 - Comparison between fissures, cracks and cracks [8]

II. INFILTRATIONS, STAINS, EFFLORESCENCE AND MOLD OR MILDEW

According to Miotto [7], the main pathological manifestations found in buildings are: infiltrations, stains, efflorescence and mold or mildew. The definition of these pathologies, in particular, will be fundamental for carrying out the case study that will be presented later.

According to Arivabene [2] we can define

infiltration as being "the result of a process in which the amount of water in contact with a substrate is so great that it flows or even drips through that substrate". Based on this, we can define a stain as the water that adheres to this substrate.

Efflorescence is defined by Shirakawa apud Lottermann [5] as "salt formations on the surfaces of walls, brought from inside by humidity". These saline formations appear under the surface of the paint or plaster with a whitish appearance and can be caused by numerous factors, some of which are the high content of soluble salts and/or excess water in the materials, as well as due to impurities present in the material. sand used to prepare the concrete used in the building.

Finally, mold or mold is defined by Arivabene [2] as being "the colonization by different populations of filamentous fungi on different types of substrates, which form undesirable dark spots in black, brown and green tones". The main difference between mold and mildew is that mold is extremely harmful to the structure of the building and if not treated, it can completely corrode the surface of the materials.

Figure 2 - Efflorescence on masonry wall [6]

III. CORROSION OF ARMATURES

According to Ferreira [3], "corrosion, in general, is the destructive interaction between a certain material and the environment in which it is found, with an electrochemical or chemical reaction occurring". It is noteworthy that this phenomenon can be accelerated due to the presence of external or internal chemical agents in the concrete.

This way, we can say that the reinforcement corrosion that occurs in concrete structures is a process of degeneration of the metallic part, which implies the progressive loss of the section of the steel bars of the reinforcement. This process occurs as a consequence of the depassivation of the reinforcement, which happens for two reasons: the presence of chlorides in the concrete or the decrease in concrete alkalinity caused by carbonation (FERREIRA [3]).

According to Miotto [7], the anomalies caused in the concrete by corrosion of the reinforcement are usually manifested by cracks in the concrete parallel to the direction of the reinforcement, which ends up delimiting or even detaching the coating.

However, it is important to point out that not always when the reinforcement is corroded does the appearance of cracks occur. In some cases, red spots produced by iron oxides may appear on the surface of the concrete. When this occurs, the structures are mainly affected by the loss of reinforcement section and also by the impairment of the adhesion between steel and concrete (FERREIRA [3]).

METHODOLOGY

The case study was adopted for the development of this research, one of the most used research methods for the study of pathologies in buildings. Therefore, the research was planned to be carried out through a logical sequence of actions that is described below (Figure 3):

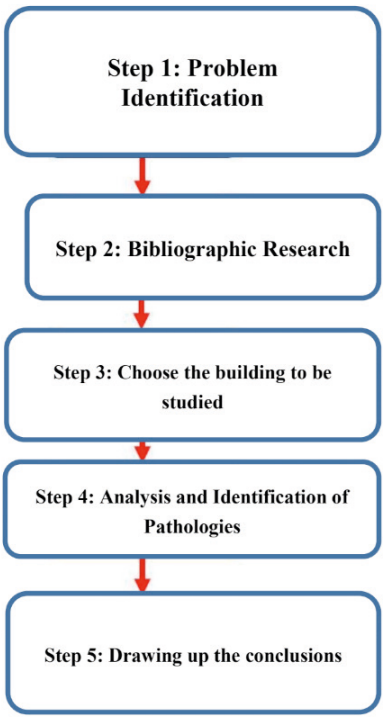

Figure 3 - Flowchart of research development steps

- First step: Identification of the problem to be analyzed, in the case of this study, the pathological manifestations that occur in residential buildings;
- Second step: Bibliographical research on the problem in question to support the ideas and correct identification and analysis of the pathologies found in the study area;
- Third step: Choice of the building to be studied and photographic record of the main pathological manifestations found in the place;
- Fourth step: Analysis and identification of the pathologies found in the study area and determination of the possible causes for the occurrence of these anomalies.
- Fifth step: Elaboration of conclusions about the studies carried out from all the information collected.

CASE STUDY

BUILDING DESCRIPTION

The Building, object of study of this research, is located on Rua Ricardo Hardman, in the neighborhood of Graças, one of the noblest neighborhoods in the city of Recife-PE, and is shown in Figure 4.

Figure 4 – Front view of the building under study

It consists of a tower with 12 floors, 10 of which are apartments (2 per floor), a pilotis and a semi-underground garage floor. In total, the building has 20 residential apartments, where each apartment has 123 m² of private area.

The building is more than 50 years old and there has been almost no preventive maintenance during all this time. Due to this, the building has been suffering from various pathologies on practically all floors. According to reports from residents, a company was hired to make a specialized technical report for the entire building and the necessary structural repairs have already been started in some parts of the pilotis area.

For this study, only the garage floor will be analyzed. This floor is semi-underground and its choice was made due to the bad conditions that the area is currently in. The pathologies

found on the pavement under study are presented below. Figure 5 shows the floor plan of the garage, as well as the location of pathologies on the floor.

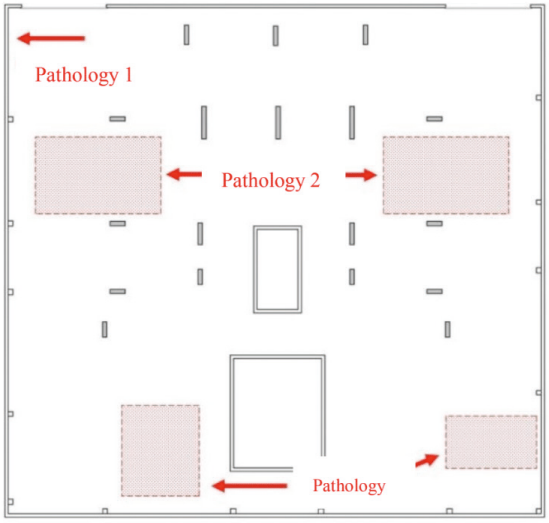

Figure 5 – Garage plan and location of pathologies

DESCRIPTION OF THE PATHOLOGIES FOUND

I. MOLD FORMATION ON GARAGE FLOOR WALL

- Visual description: The figure shows the wall next to the exit gate and entrance of cars on the garage floor full of stains, some of which already have a very greenish tone.

- Manifestation: Some areas, when very close to hydraulic elements or even due to lack of sunlight, may end up suffering from the presence of fungi that end up aesthetically damaging that place.

- Probable causes: It can be seen from the figure that the main causes for this pathological manifestation are the presence of a lot of humidity in the environment and also the absence of sunlight in this area, since the masonry is further back in relation to the pillars and beams. There may also have been a waterproofing problem in the area, probably due to lack of maintenance on the part of the users of the building or failure by the company responsible.

- Mechanism of occurrence: Due to the lack of sunlight, high humidity and lack of proper maintenance at the site, there was a large proliferation of fungi that tends to increase over time if proper corrective maintenance is not carried out.

- Solutions: To treat this type of pathology, you must first treat the cause of this manifestation. Therefore, you must scrape and clean the entire area affected by the mold, and then proceed with a correct waterproofing of that place to reduce the effects of humidity. After that, the area must be repainted with paint with fungicidal action to prevent the appearance of new fungi.

Figure 6 - Formation of mold on the wall of the garage floor

II. INFILTRATIONS IN THE GARAGE FLOOR CEILING WITH STALACTITE FORMATIONS

- Visual description: The figure shows the roof of the garage floor with greenish spots and the appearance of white stalactites in the darkest part of these spots.

- Manifestation: The appearance of stalactites demonstrates the presence of the leaching process that occurs in this slab, where water penetrates into the pores and is transported along with the salts to the external surface of the concrete.

- Probable causes: It can be seen from the figure that the main cause for this pathological manifestation is some infiltration that is occurring in the slab that separates the pilotis floor and the garage floor. It can be seen that this infiltration has been occurring for some time due to the coloration of the ceiling, which is already quite green and also due to the formation of the various stalactites scattered by the infiltration stains.

- Mechanism of occurrence: As there are infiltrations in this slab, the leaching process ended up occurring in this concrete. As time went by, the water infiltrated more and more, dragging the calcium hydroxide present in the concrete with it, thus resulting in stains and stalactites on the slab.

- Solutions: In order to treat this type of pathology, first, a study of the level of severity that this pathology caused in the structure must be carried out. After this analysis, if it is something simple, you must clean the entire part affected by the infiltrations and scrape the entire part contaminated by calcium carbonate. However, if the situation is more serious, structural reinforcement must be carried out on this slab to avoid corrosion of the reinforcement and possible collapse in the future.

Figure 7 - Infiltrations in the ceiling of the garage floor with stalactite formations

III. INFILTRATION AND EXPOSURE OF REINFORCEMENT IN THE GARAGE FLOOR CEILING

- Visual description: The figure shows the roof of the garage floor and a sewer pipe, where a 90° elbow and approximately 100 mm in diameter is serving as a drain to capture water from the upper floor (pilotis).

- Manifestation: Hydraulic pipes connected to reinforced concrete structures must be very well waterproofed so that there are no leaks that could affect and damage the useful life and durability of the structural elements that are around them.

- Probable causes: It can be seen from the figure that the main cause for this pathological manifestation is the poor waterproofing of the drain in the pilotis,

since the entire part around the pipe is suffering from infiltration.

- Mechanism of occurrence: Due to the absence of proper waterproofing, the water coming from the stilts infiltrates the slab and ends up leaving the garage ceiling full of brownish stains. It is also noticed that due to the infiltrations, the ceiling coating is falling, which is leading to the exposure of the reinforcement and its consequent corrosion.

- Solutions: To treat this type of pathology, you must first properly waterproof the stilt floor drain to prevent further infiltration. Next, the corrosion of the exposed reinforcement must be treated by scraping the rusted part and applying a corrosion inhibitor product to prevent further corrosion. Finally, the infiltrated area is recovered by scraping and carrying out a new application of paint and plaster.

Figure 8 - Infiltration and exposure of reinforcement on the roof of the garage floor

CONCLUSION

From the development of this research, it was possible to conclude that the building under study presented several types of pathological manifestations, ranging from simpler pathologies to pathologies that require greater care. Among the types of pathological manifestations found, the infiltrations that are occurring in several points of the slab that separates the garage from the stilts stand out and are causing stalactites, and also the exposure and consequent corrosion of the slab reinforcements, a more serious pathology that it is occurring in locations other than those presented in this study.

It is worth noting that from a naked eye analysis it can be stated that the pathologies found are at levels considered serious and require immediate repairs so that they do not cause more serious impacts to the structure of the building. However, to determine more precisely the level of severity of the pathologies and how they are affecting the integrity of the structure, more detailed analyzes will be required not only of the garage structures, but also of the entire building.

Another important point worth mentioning is that most of the pathological manifestations found in this study, as well as several others present in different buildings, can be avoided if periodic preventive maintenance is carried out in the buildings, something rarely done in the building under study. In addition to prevention, periodic maintenance is also extremely important to identify possible pathologies in buildings in their early stages, which facilitates their treatment, causing little or no damage to the structure.

Finally, it is hoped that this work can contribute to the study and development of new techniques for identifying, correcting and treating the pathological manifestations mentioned in this research.

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