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About the mapping of reinforced concrete columns with pathological manifestations: Case in buildings belonging to the public university

Giovana Viscardi Fernandes[1], Poliana Bai Naldo[2], Cesar Fabiano Fioriti[3].

ABSTRACT

This work is a case study through the mapping of pathological manifestations identified in reinforced concrete pillars of buildings belonging to the Faculty of Science and Technology of UNESP (FCT/UNESP), located in Presidente Prudente, São Paulo. In the field, a survey of anomalies in the buildings under study was carried out using digital images. The information obtained was gathered and organized with the respective locations on campus of the images collected and captions that indicate the type of anomaly present – cracking, staining, detachment, exposure of reinforcement with corrosion or niche – by means of different shapes and colors. It was then analyzed, with the aid of a quantitative graph, that the types that appeared most frequently were exposure of reinforcement with corrosion, cracking and detachment, showing that maintenance and/or repair programs should be carried out.

Keywords: Deterioration, Structures, Degradation, Structural system.

INTRODUCTION

According to Silva (2011), the pathological manifestation can be defined as the expression that results from a degradation mechanism, which differs from the term "pathology", used to designate the science that comprises a group of theories that enable the explanation of the mechanism and the cause of the appearance of the occurrence of a precise pathological manifestation. Thus, it is analogous to a "symptom" of a disease.

According to Alencar (2017), the occurrence of such anomaly is caused by the inexistence or insufficiency of planning and execution of the work, misuse of the construction and lack of maintenance. In addition, it is associated with all phases of construction: from project conception, selection of materials and execution, including structures, installations, seals, roofs and finishes, to use.

It is worth mentioning the potential of this problem to affect the performance of the building, resulting in the loss or impairment of its functions, whether of a mechanical, functional or aesthetic nature. If the study and treatment of pathological manifestations are not carried out, according to Silva (2021), economic problems can be generated due to the loss of the work and social problems arising from the risk to the safety of users.

[1] Faculty of Science and Technology of the São Paulo State University – FCT/UNESP – SP
[2] Faculty of Science and Technology of the São Paulo State University – FCT/UNESP – SP
[3] Faculty of Science and Technology of the São Paulo State University – FCT/UNESP – SP

This disease can be observed in reinforced concrete structures, consisting of cement, water and aggregates – sand and stone – together with steel. Concrete has high compressive strength and weak tensile strength, so steel was added to it, which has high tensile and compressive strength. According to Adão and Hemerly (2010), the combination of the two was allowed by the proximity of their expansion coefficients: 0.0137 mm per 1 ºC and 1 linear m for the concrete material, and 0.0125 mm per 1 ºC per 1 linear m for the steel material.

The interactions present in reinforced concrete make it vulnerable to changes over time. ABNT NBR 15575 (2024), responsible for dealing with the performance of residential buildings, stipulates that the works have to have a minimum useful life of 50 years, however, these changes are capable of reducing this minimum estimated life for construction.

An example of an affected structure is the abutment. Pillars are structural elements that, according to Adão and Hemerly (2010), aim to receive, mainly, vertical loads that fall on the floor of the building, transmitted by the actions of beams. Such actions are predominantly compression, therefore, because it has high resistance to this type of stress, concrete is used.

Pathological manifestations in the pillars can be related to cracks, stains, displacements, exposure of reinforcement with corrosion, niches, deficient covering, among others. Fissures, according to the Engineer Civilization Blog (2018), are narrow, elongated openings in the surface of a material. Compared to cracks and cracks, which are more pronounced openings, fissures have lower gravity and greater shallowness. In addition, it is worth mentioning that cracks give rise to cracks.

The spots, in turn, are due to problems related to humidity (VERÇOZA, 1991 *apud* SILVA *et al.*, 2022). These problems often arise with water seeping into the structure. According to Martins and Fioriti (2015), the spots are characterized as dark and white, and the former differ in the proliferation of fungi and mold as the cause, and the latter in the leaching process.

In addition to these, there are the displacements. According to Souza and Ripper (1998), they occur as a consequence of the generation of fissures – those mentioned above. Especially, there is the detachment of the concrete covering (protection) of the reinforcements.

In sequence, the type of manifestation called exposure of reinforcement with corrosion is scored. Also according to Souza and Ripper (1998), in these cases, the concrete ends up disaggregating when there is an increase in the volume of the metal bars, or even when expansive reactions arise (which ends up resulting in a process that disaggregates the material in a somewhat frenetic way).

Another pathological manifestation is niches. They have the following general aspects: apparent voids both in corners and in the lateral parts of beams and columns, perception of coarse aggregates without mortar involvement and concrete without homogeneity. The causes are, among others: mistakes in

launching and densification, excess reinforcement that retains the aggregates allowing only the passage of mortar, excess of coarse aggregates (MARTINS and FIORITI, 2015).

Finally, as an anomaly of a building, there is poor covering. The cover is the protective layer of the reinforcement, therefore, according to Souza and Ripper (1998), its deficiency is responsible for facilitating the implementation of deterioration processes that trigger the corrosion of reinforcement, by providing a greater connection of external harmful agents.

OBJECTIVE

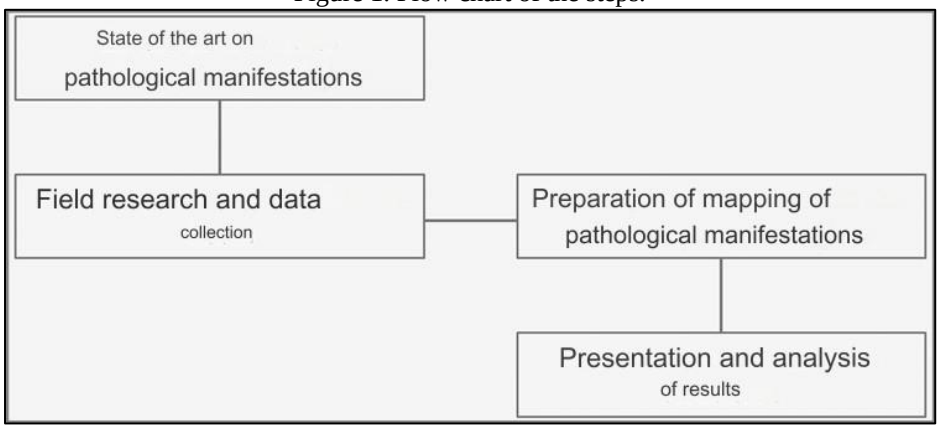
The aim of this work was to develop a case study through the mapping of pathological manifestations found in reinforced concrete pillars belonging to public university buildings, in this case, the Faculty of Science and Technology of UNESP (FCT/UNESP), located in Presidente Prudente – SP. In addition, it provided the identification of the main and most occurring anomalies found in the aforementioned objects of study.

Thus, it is worth mentioning that the objective was not to discuss possible causes of the problems encountered, as well as feasible solutions. In other words, there was a focus on identifying and mapping irregularities in the constructions.

METHODOLOGY

According to Martins (2008), the case study fits into a methodological strategy used in research, such that it can be applied in evaluation or even description processes involving dynamic situations in which the human being is present. Also according to the aforementioned author, its application makes it possible to create, understand, describe and interpret the degree of complexity of the case analyzed. Next, the flowchart of the steps developed in the fieldwork will be presented (Figure 1).

Figure 1. Flow chart of the steps.



Like this:

1st Stage: Study of the generalities of the pathology in reinforced concrete elements, which aimed to obtain theoretical support for its further development.

2nd Stage: On-site inspections of the buildings under study, in order to identify (symptomatology) the anomalies existing in the pillars for the execution of their mapping.

3rd Stage: Presentation of the mapping of the pathological manifestations identified in the apparent pillars, containing their general aspects. The mapping consisted of a color legend, based on Silva *et al.* (2022), which made it possible to identify each type of pathological manifestation detected (Figure 2). The images were obtained using a semi-professional Nikon camera (model COOLPIX P600), which was framed by an aluminum tripod. The inspection level classification presented by the IBAPE standard (2012) was adopted, as shown in Chart 1, also as in Silva *et al*. (2022), in which the technical characteristics of the building are considered, combined with the maintenance and operation project.

Figure 2. Legend used in anomaly mapping.

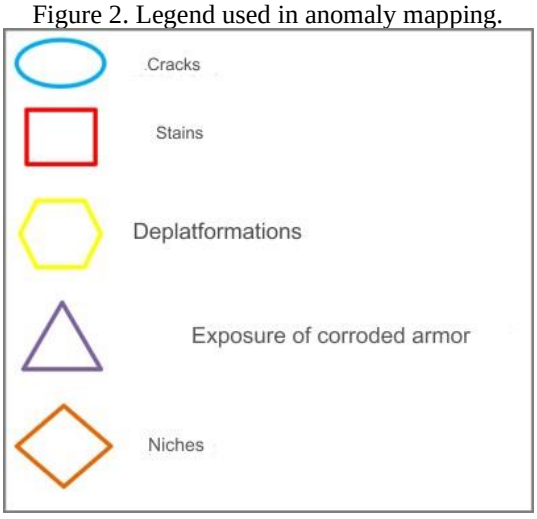


Table 1. Classification according to the level of inspection.

Level	Considerations
1	"Carried out in buildings with reduced technical complexity, maintenance and procedure of their elements and construction systems. Used in buildings with a maintenance program considered simple or even non-existent".
2	"Carried out in buildings containing medium technical complexity, maintenance and procedure of their elements and construction systems. Used in buildings with multiple floors, whether or not they have a maintenance program."
3	"Carried out in buildings containing high technical complexity, maintenance and procedure of their elements and construction systems. Used in buildings with multiple floors or with construction systems equipped with automation".

Fonte: IBAPE (2012).

4th Stage: Presentation of the mapping of pathological manifestations, with the support of analysis by means of quantitative graphs generated by Excel software.

DEVELOPMENT

Figures 3 and 4 show the delimitation of the chosen study site – FCT/UNESP – under satellite view and the buildings in which there were records of pathological manifestations, with the addition of legends indicating which one each building corresponds to.

For a better view, the UNESP campus was divided into 2: north and south of Roberto Simonsen Street.

Figure 3. Satellite view of FCT/UNESP to the north of Roberto Simonsen Street, highlighting the buildings in which there were records and the addition of legends.

Source: Google Maps – edited.

Figure 4. Satellite view of FCT/UNESP to the south of Roberto Simonsen Street, highlighting the buildings in which there were records and the addition of legends.

Source: Google Maps – edited.

Among the images recorded in the field, 10 were chosen, considered more relevant for the development of the article in question. They are presented below in Tables 2, 3, 4, 5 and 6, containing their corresponding legends.

In the building where the Center for Study and Research in Education, Playfulness, Childhood and Youth is located, the following pathological manifestations were recorded:

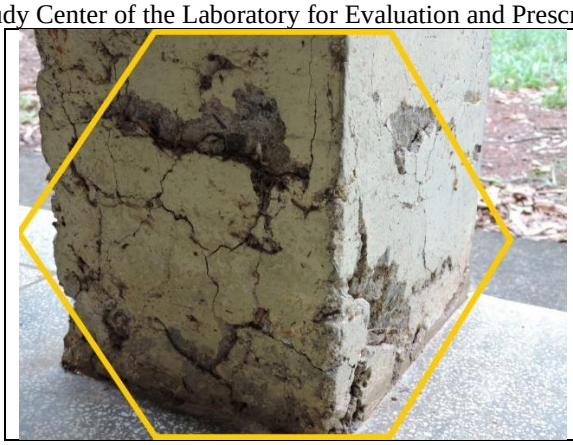
Table 2. Mapping of pathological manifestations – Center for Study and Research in Education, Playfulness, Childhood and Youth.

	Pathological manifestation: Stains
	Pathological manifestation: Cracks

Source: Authored by the authors.

In the building where the Department of Physical Education, the Department of Physiotherapy and the Study Center of the Laboratory for the Evaluation and Prescription of Motor Activity are located, there are:

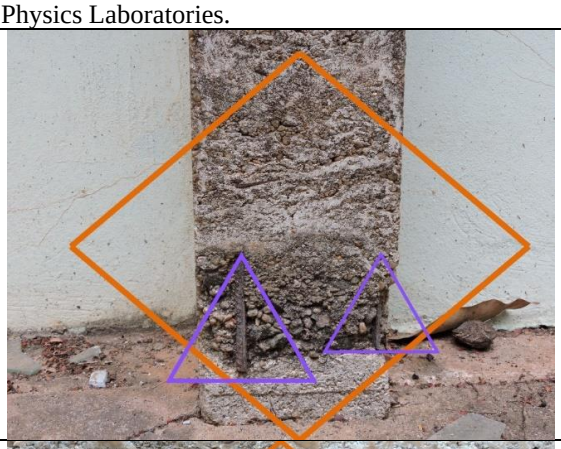
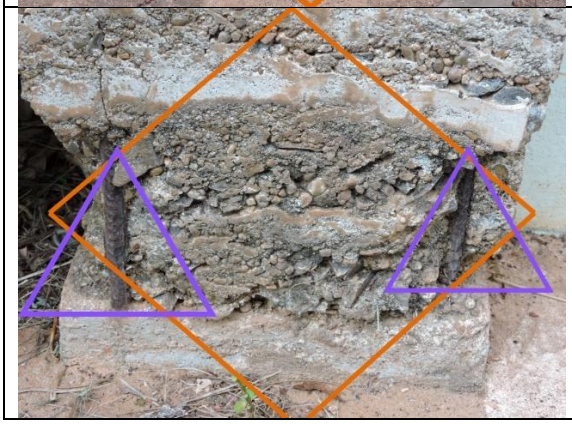
Table 3. Mapping of pathological manifestations – Department of Physical Education, the Department of Physical Therapy and the Study Center of the Laboratory for Evaluation and Prescription of Motor Activity.

	Pathological manifestation: Deplatformations

Source: Authored by the authors.

In the building of the Geology, Geomorphology and Water Resources Laboratory and the Physics Laboratory Center, the following were identified:

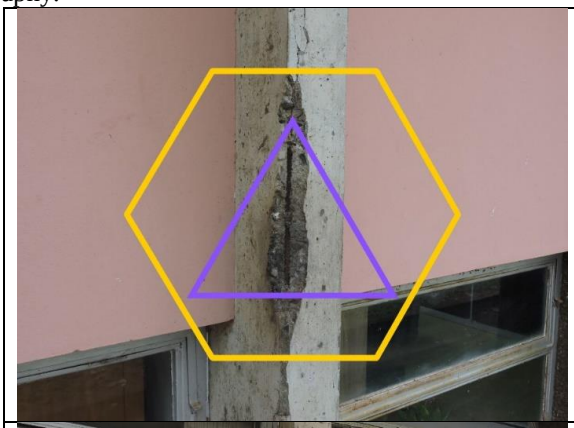
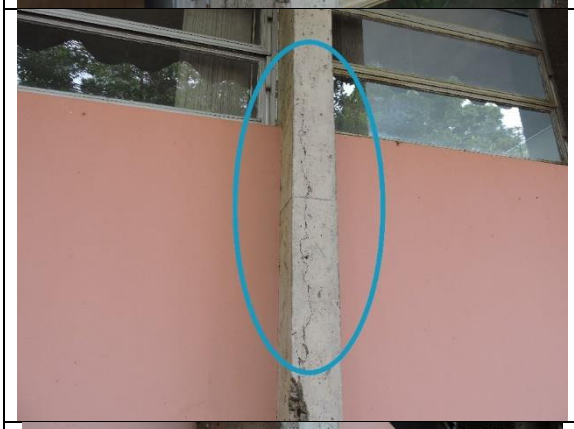
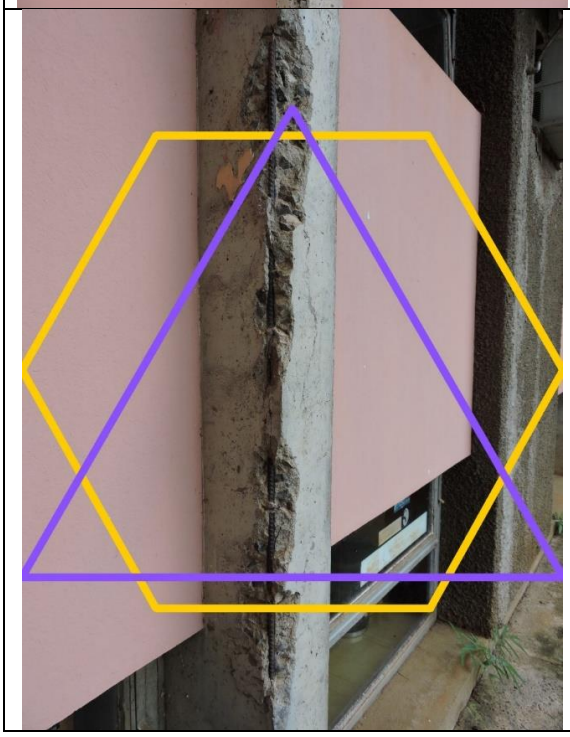
Table 4. Mapping of pathological manifestations – Laboratory of Geology, Geomorphology and Water Resources and the Central Physics Laboratories.

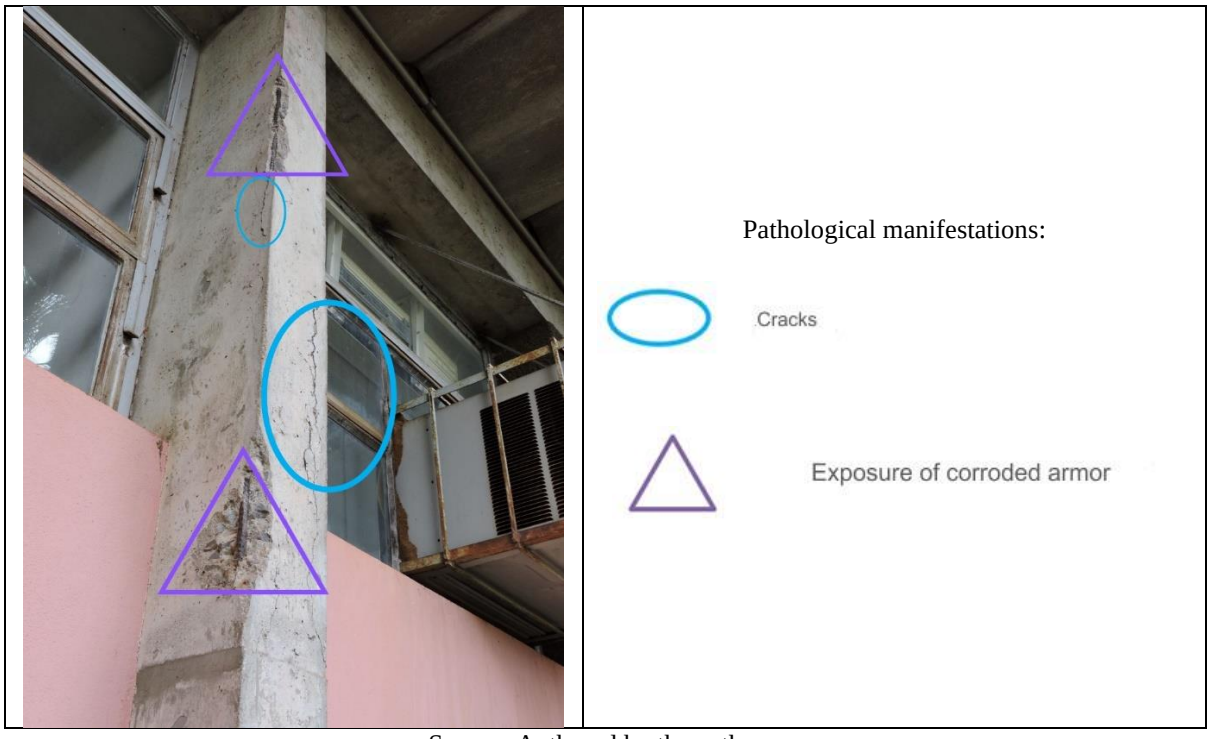
	Pathological manifestations: Exposure of corroded armor Niches
	Pathological manifestations: Exposure of corroded armor Niches

Source: Authored by the authors.

In addition, in the building of the Department of Planning, Urbanism and Environment, which also houses the Department of Cartography, the following anomalies were captured:

Table 5. Mapping of pathological manifestations – Department of Planning, Urbanism and Environment; Department of Cartography.

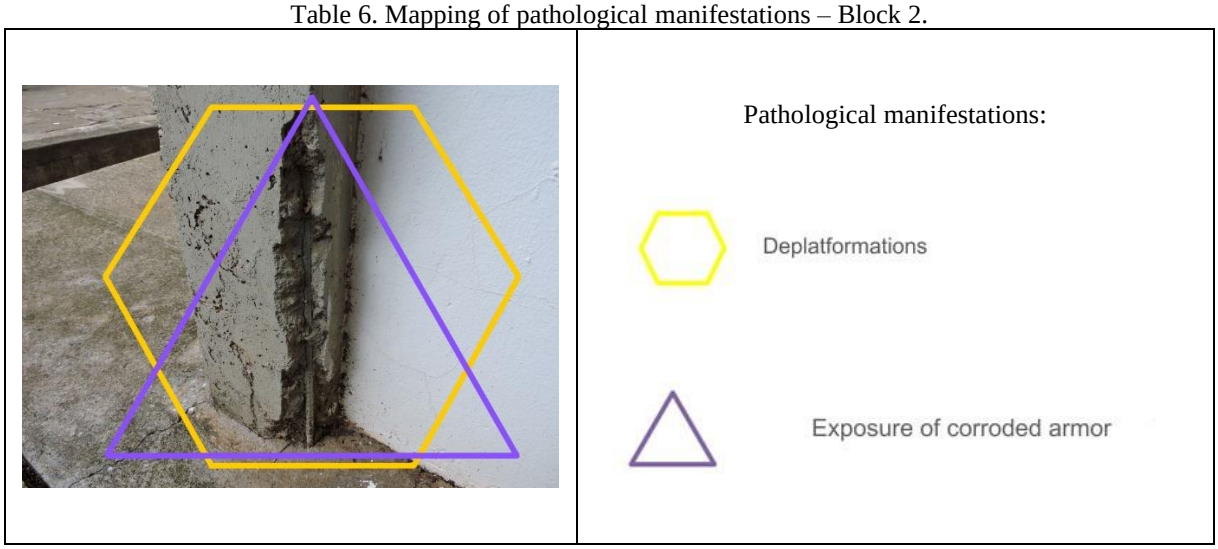
	Pathological manifestations: Deplatformations Exposure of corroded armor
	Pathological manifestation: Cracks
	Pathological manifestations: Deplatformations Exposure of corroded armor



Source: Authored by the authors.

Finally, in Block 2, we have the following occurrences:

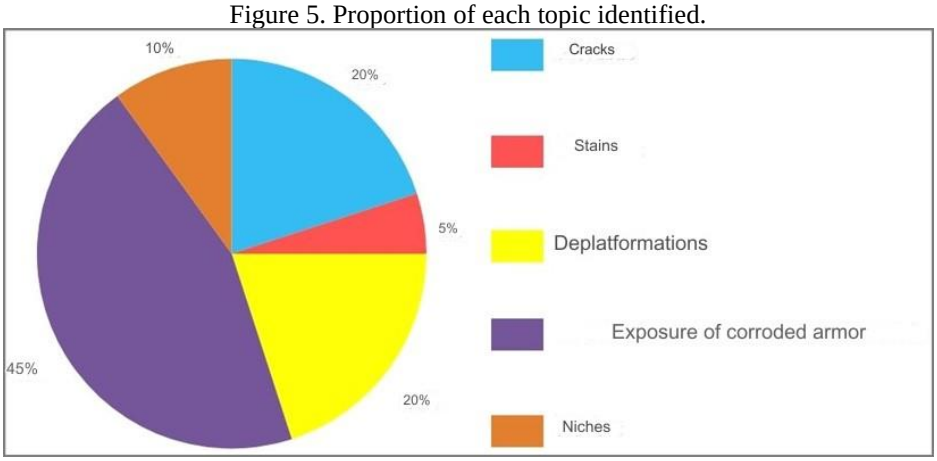
Table 6. Mapping of pathological manifestations – Block 2.



Source: Authored by the authors.

It can be seen that, among the 20 pathological anomalies identified and presented in Tables 2 to 6, the most recurrent among the records analyzed was the exposure of reinforcement with corrosion, with 9 recorded, followed, respectively, by cracking and detachment, with 4 records of each; the niche, with 2; and the stain, in 1. Based on this, a graph was generated (Figure 5) that shows the relationship of the proportions found for each topic cited.

Figure 5. Proportion of each topic identified.



Finally, with reference to Chart 1, it is possible to fit the pathological manifestations studied in the level 1 inspection classification presented by the IBAPE standard (2012), and they are present in buildings with one floor; reduced technical complexity, maintenance and procedure of its elements and construction systems; and simple or non-existent maintenance program.

FINAL THOUGHTS

In view of the problems pointed out, the types of anomalies that appeared most frequently were exposure of reinforcement with corrosion, cracking and detachment. Itshould be noted that the lack of maintenance and operation of the elements can interfere with both the performance of the building and its aesthetics. In addition, it is capable of shortening the useful life of buildings. Thus, there is a need for constant inspections and maintenance programs in order to prevent and mitigate such consequences.

REFERENCES

Adão, F. X., & Hemerly, A. C. (2010). Concreto armado: Novo milênio: Cálculo prático e econômico. Rio de Janeiro: Interciência.

Alencar, J. C., Lima, A. N., & Lima Junior, W. J. (2017). Manifestações patológicas em estruturas de pilares de concreto armado no centro de saúde José Bandeira de Medeiros em Delmiro Gouveia-AL. In IV Ereec (pp. 1–10). João Pessoa-PB.

Associação Brasileira de Normas Técnicas – ABNT. (2024). NBR 15575: Edificações habitacionais – Desempenho. Rio de Janeiro.

Blog Civilização Engenheira. (2018, April 4). Conheça as principais patologias na construção civil. Retrieved May 18, 2023, from https://civilizacaoengenheira.wordpress.com/2018/04/04/conheca-as-principais-patologias-na-construcao-civil/

Instituto Brasileiro de Avaliações e Perícias de Engenharia – IBAPE. (2012). Norma de inspeção predial nacional. São Paulo, 18p.

Martins, G. A. (2008). Estudo de caso: Uma reflexão sobre a aplicabilidade em pesquisas no Brasil. Revista de Contabilidade e Organizações, 2(2).

Martins, J. F. A., & Fioriti, C. F. (2015). Abordagem de manifestações patológicas em sistemas estruturais de edificações públicas nas cidades de Sevilla (Andalúcia, Espanha) e Presidente Prudente (São Paulo, Brasil). In IX CICFAI – Congresso de Iniciação Científica das Faculdades Adamantinenses Integradas (pp. 1–17). Adamantina.

Silva, A. F. P., Barros, H. E. B., Ferreira, D. S., Nascimento, L. G., Lima, F. E. G., & Bezerra, L. de O. (2021). Patologias em estruturas de concreto armado: Estudo de caso. Brazilian Journal of Development, 7(1), 363–374.

Silva, A. P., Silva, D. M., Sousa Neto, J. L., & Silva, E. S. (2022). Identificação de manifestações patológicas em elementos de concreto e concreto armado: Um estudo de caso no campo de futebol Lazaro Paiva (Lazarão) em Mossoró/RN. Monografia de Trabalho Final de Graduação (Engenharia Civil) – Ânima Educação.

Silva, F. B. (2011). Patologia das construções: Uma especialidade na engenharia civil. Téchne, 174(19), 1–10.

Souza, V. C. M., & Ripper, T. (1998). Patologia, recuperação e reforço de estruturas de concreto. São Paulo: Pini.