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Identification of pathologies and maintenance techniques in a semi-buried reservoir

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ABSTRACT
In the structured reservoirs of reinforced concrete, among the most incident pathological manifestations are the corrosion of the reinforcements, cracks and cracks in the roof or bottom slab, infiltrations and deterioration of the concrete. Identifying such pathologies is essential to ensure the safety, durability and efficiency of the structures, as well as to avoid excessive expenses and waste of resources during the recovery of the same. This article aims to present the pathologies in semi-buried water reservoirs of reinforced concrete, taking as an example a Votuporanga reservoir, and to analyze possible recovery techniques to be applied. After sensory analysis of the reservoir under study, several pathologies were identified, such as cracks, cracks, deterioration of waterproofing, peeling of paint, corrosion of the pipe, mold and mildew. Based on the diagnoses, procedures such as resin injection, cleaning and painting of oxidized metal elements, mold removal and application of waterproofing can be performed. The proper use of maintenance techniques and appropriate materials prove to be effective in the rehabilitation of reservoirs, ensuring water quality and extending the useful life of structures.

Keywords: Semi-buried reservoir of reinforced concrete, Building inspection, Pathological manifestations, Recovery techniques.

1 INTRODUCTION

The need to use water for supply is indispensable for humanity, and with the increase in population the demand for water also increases. In order to overcome the problem of water availability, other resources have been used as a means of preserving water sources (ANGRILL et al., 2012).

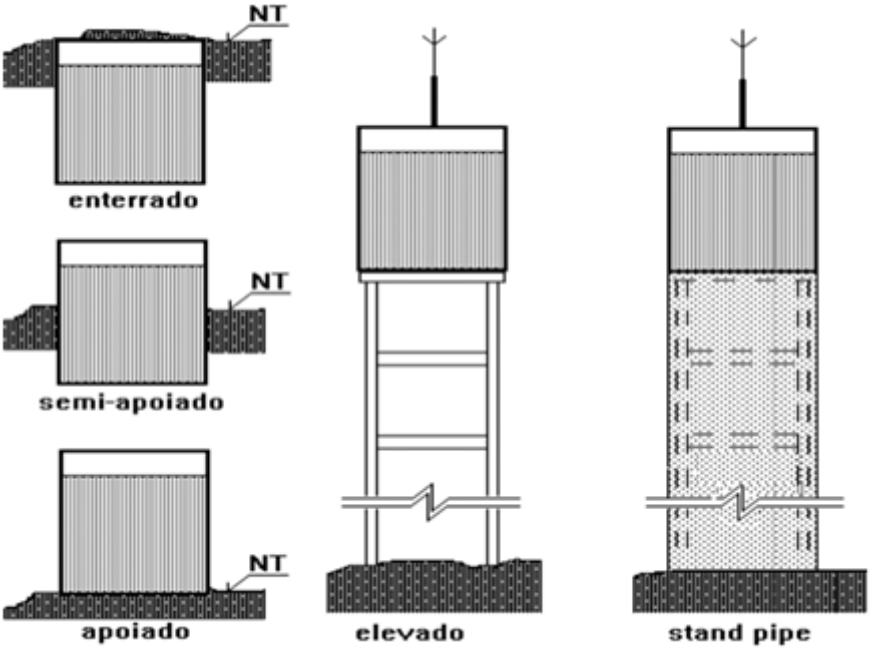
Thus, there is a need to reserve large volumes of water in reservoirs, so that during peaks of consumption or even times of drought or disasters, the city still has water for the population.

According to Gonçalves (2008) the reservoirs are classified according to their implantation in the field in (Figure 1):

- Buried: This reservoir is built entirely below ground level.
- Semi-buried or semi-supported: only a part of the height of the constructed reservoir is located below the level of the land;
- Supported: it is built fully above the level of the terrain and the bottom slab remains supported on it;
- High: reservoir is built and supported on a lifting structure;

- *Stand Pipe*: is a raised reservoir with the built-in lifting structure, keeping the perimeter of the cross section continuous.

Figure 1 – Example of reservoirs according to their implementation



Source: Gonçalves (2008)

Reservoirs can be built with a variety of materials, and the choice of these materials depends on the conditions of the terrain and the specific needs. With this, we have some examples:

- Stainless steel: The reservoir is composed of stainless steel. Due to the properties of the material, they are more focused on beverage and food production activity (SANSUY, 2021).
- Reinforced polyester: They are polyester reservoirs reinforced with glass fibers, which provide an increase in their resistance to mechanical, chemical and corrosion actions, being indicated for large volumes of water and having easy installation (SANSUY, 2021);
- Concrete: They are reinforced concrete reservoirs, their water reserve capacities vary according to the project, allowing to meet various demands (SANSUY, 2021).

Reinforced concrete undergoes changes over time, due to the interaction of the mixture materials with external agents, such as weathering. Often, these interactions result in anomalies that can compromise the performance of the structure, cause undesirable aesthetic effects or cause psychological discomfort in users (AECweb/e-Construmarket, 2012).

As in medicine, the term pathology refers to diseases or abnormalities, and this term is also used in engineering to describe the abnormalities that arise in the structures of buildings, called pathological manifestations, so that, over time and without maintenance processes, these manifestations are intensifying, damaging and compromising the structure (LAUREN, 2010).

From this, an area of innovative studies called "Pathology of Structures" emerged, which focuses on the investigation of the origins of pathological manifestations, their behavior and the problems that the structures have suffered. These pathologies represent the main challenges that compromise the safety, aesthetics and durability of buildings (LAUREN, 2010).

As highlighted by Souza and Ripper (1998), the Pathology of Structures is not limited only to the identification and knowledge of anomalies, but is fundamental in the training of civil engineers. Therefore, in addition to learning in design and execution, it is also necessary to master the recovery and maintenance of existing buildings, ensuring their safety, useful life and future performance capacity.

Pathological manifestations in semi-buried reservoirs can arise in different forms such as cracks, cracks, deterioration of waterproofing, peeling of paint, corrosion of pipe, mold and mildew, among others. The study of these manifestations aims to discover their causes, enabling the prevention of future works with safe maintenance, in order to ensure that the structure is conserved and allow comfort and safety to users (ALEIXO, 2018; DE MARCHI, 2021).

A factor that can cause pathologies in the structures is the repression or sinking of the soil near it, being a consequence of a load on the soil, soil vibrations and / or water leakage. The repression generates a reaccommodation of the soil particles, reducing the volume of the same in the surroundings of the building, which, depending on the intensity of the deformation, can result in serious damage to the superstructure of the building and to avoid it is important to understand the characteristics of the soil and its load bearing capacity. Compaction or drainage techniques can be adopted to minimize the effects of repression and ensure soil resistance (TECHNIQUES, 2020).

If there is the repression of the soil, cracks and cracks appear in the structure, as in the case evaluated in this article, causing water infiltration, appearance of stains and molds, in addition to other problems.

Cracks and cracks can be considered as defects, causing visual discomfort to the user of the building. Even harming the aesthetics, most of the time they are consequences of the movement of the construction, being common mainly in works made in reinforced concrete (SANTANA, 2017).

According to NBR 15575-2 (ABNT, 2013) cracks are sectionations on the surface or throughout the cross-section of the structure, which were caused by normal or tangential stresses. They are classified as active (there is variation in the size of the opening due to hygrothermal movements) or passive (when the size of the opening is constant).

Sealing is a technique used in cracks greater than 10mm and aims to seal the crack using adherent material, with chemical and mechanical resistance, such as *grout* and in some cases epoxy (SOUZA AND RIPPER, 1998).

To close cracks, the injection process with hydroexpansive polyurethane is used to solve water leakage problems. The injection technique is widely used to end water infiltrations. When the hydroexpansive polyurethane comes into contact with water or moisture, it promotes an almost instantaneous expansion relationship, forming a solid foam barrier with closed cells, filling and waterproofing cracks, cracks and pores through which water has access (MONGE, 2002).

Another possible pathology in reinforced concrete reservoirs is mold/mildew. According to Shirakawa (1995) it is titled as mold / mildew the growth of fungal colonization on a substrate, causing spots in dark tones, which, once not treated can increase the proliferation of fungi. The main causes for mold/mildew and water accumulation to manifest themselves are, the relative humidity around 80%, the condensation of vapors indoors and the rising humidity by capillarity.

The removal method is a cleaning service that consists of washing the affected areas, with a nylon brush and with a high pressure washer, and after drying, must pass a waterproofing for the protection of the same (FONSECA; ROCK, 2021).

Another common form of pathology found in reservoir is rust and corrosion of the pipes present, which are chemical processes that affect materials, especially metals, and can cause significant damage to metal pipes. According to Gentil (2003), corrosion comes from the oxidation of the metal present in the structure that was exposed to the action of water and oxygen, generating rust.

To perform the treatment of rust it is important to observe if the structure has not been compromised, if it is compromised it is necessary to change the pipe. For the removal of rust, sandpaper and/or a steel brush is used. After removal, the surface should be cleaned with cloth moistened in *Thinner*, so that later you can apply the protective paint (ALEN SOBRINHO and CONTRERA, 2016). All cleaning procedures must follow the recommendations of ISO 8501.

The reinforced concrete reservoirs may also present wear in the painting, when evaluating the external area of the structure, and deficiencies in the internal waterproofing of the reservoir, which end up compromising the functionality and operation of the same.

Waterproofing, in addition to ensuring the habitability and functionality of the building, it plays a key role in protecting against a number of pathological problems caused by water infiltration, along with oxygen and other aggressive components present in the atmosphere (CRISTINA, 2020).

With the deterioration of the waterproofing of asphalt blanket, causing loss of functionality, it is necessary to perform all the removal of the waterproofing, by scraping process with brushes with steel bristles and hydro blasting, in order to ensure a more adherent surface, eliminating any type of elements that impair the interaction with the new waterproofing of asphalt blanket (CRISTINA, 2020).

According to Do Carmo (2003), paintings are always considered as finishing materials, and may have the function of waterproofing surfaces. They may suffer wear and/or deterioration from constant exposure to the elements.

There are several causes that generate pathologies in paintings, so they have several intervention alternatives, the most recommended being to completely remove the damaged paint and apply a new layer (ZUCHETTI, 2015).

When it comes to concrete material, a common phenomenon that occurs in water reservoirs is leaching. According to NBR 6118 (ABNT, 2014), leaching refers to the process in which the compounds of the cement paste are dissolved by the action of water, so that the water penetrates the pores of the concrete, dissolving the calcium and magnesium hydroxides present in the cement paste and transporting them to the surface.

According to Martins; Fioriti (2014), the efflorescence pathology is a consequence of leaching and is characterized by white spots on the concrete surface of the structures. According to Souza and Ripper (1998), the increase in the porosity of the concrete, resulting from the process of carrying the compounds, contributes to the dissolution, transport and deposition of calcium hydroxide, leading to the decomposition of other hydrates.

It is possible to remove the saline deposits by cleaning with acetic acid, however, depending on the level of degradation, it may be necessary to recompose the structure. According to AecWeb (2023), the most adopted solution to resolve efflorescences is the use of waterproofing materials on substrates with lime-free coating mortar.

According to Tinoco and Morais (2013), another pathological manifestation incident in reinforced concrete structures is corrosion in the reinforcements. The causes for this type of pathology are decrease in the thickness of the covering and increase in the porosity of the concrete, causing a negative impact on the useful life of the structure, since the physical barrier provided by the covering is reduced and becomes more fragile.

For the recovery of corroded structures in reservoirs, it is suggested to measure the affected steel area. If it does not exceed 15%, the treatment will be done without the need for adding bars, performing the repair as Piancastelli (1997) recommends:

a) remove all disaggregated concrete;

b) clean the reinforcement by removing all corrosion products with suitable brushes;

c) apply corrosion inhibiting polymers on the bar;

d) perform the repair according to the depth affected.

According to Souza and Ripper (1998), depending on the cracking state of the structural part, the deplating of the layer that coats the reinforcements may occur, leading to the acceleration of corrosion in the metal.

For the recovery of structures that are with concrete deplating, Piancastelli (1997) recommends the use of grout, following the reconstruction procedure:

a) treat the substrate and moisten it, without saturating it;

b) install shapes with pipe (Figure 2);

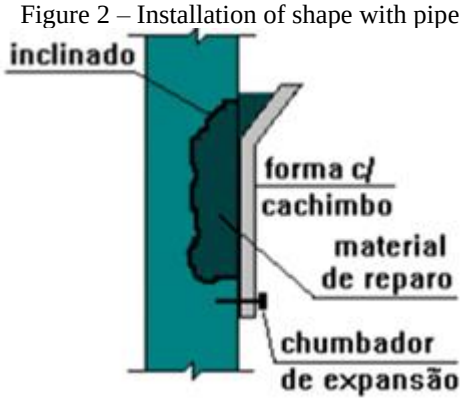
c) prepare the grout according to the manufacturer's specification;

d) throw the grout into the forms and thicken it;

e) before the hardening of the grout, deform and carefully remove its excess;

f) perform the cure.

Figure 2 – Installation of shape with pipe

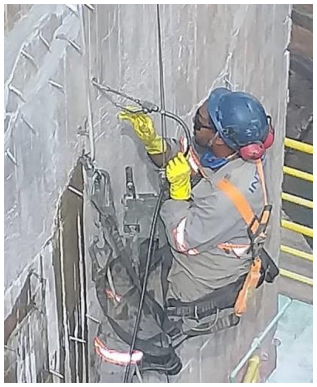


Source: Piancastelli (1997)

Figure 3 shows the main types of pathological manifestations that may occur in semi-buried reservoirs, as well as some materials used in corrections.

Figure 3: Main pathologies in semi-buried reservoirs and materials applied for their recovery

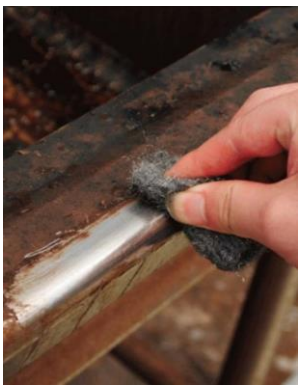
Cracks – sealing with grout. *Source: Intech Engenharia (2016)*



Cracks – injection of polyurethane. *Source: Intech Engenharia (2016)*

Waterproofing – application of blanket. *Source: Tae Magazine (2020)*

Paint deterioration – scraping. *Source: Revprol (2022)*



Corrosion – sanding. *Source: Aparecida Tubos (2022)*

Mold and mold – mold/mildew cleaning. *Source: Tricurious (2018)*

Efflorescence. *Source: Aecweb (2023)*

Corrosion in the armor Source: Silva *(2018)*

Concrete deplating *Source: Batista (2022)*

According to Lauren (2010) it is important the early detection of pathological manifestations, since, the sooner it is treated, the sooner it minimizes damage to the structure and costs with maintenance and/or recovery of the structure. For this it is necessary to make a diagnosis about the pathologies found, clarifying all aspects of the problem, such as: symptoms, mechanisms, origins and causes.

According to the Building Inspection Standard of the Brazilian Institute of Engineering Evaluations and Expertise – IBAPE, anomalies and failures are classified into three different degrees of recovery, considering the impact of the risk offered to users, the environment and heritage.

a) DEGREE OF CRITICAL RISK IRRECOVERABLE IMPACT – is one that causes damage to the health and safety of people and the environment, with excessive loss of performance and functionality, causing possible stoppages, excessive cost increase, sensitive compromise of useful life and sharp real estate devaluation.

b) DEGREE OF RISK REGULAR PARTIALLY RECOVERABLE IMPACT – is one that causes the partial loss of performance and functionality of the building, without prejudice to the direct operation of the systems, early deterioration and devaluation at acceptable levels.

c) DEGREE OF RISK MINIMUM RECOVERABLE IMPACT – is that caused by small losses of performance and functionality, especially as to aesthetics or programmable and planned activity, without incidence or without the probability of occurrence of the risks

related to recoverable and partially recoverable impacts, in addition to low or no compromise of the real estate value.

The identification of pathologies according to the degrees of recovery risks in civil engineering is fundamental to ensure the safety, durability and efficiency of structures, as well as to avoid excessive spending and waste of resources during the recovery of the structure.

Thus, this article aims to present the pathologies in a semi-buried water reservoir of reinforced concrete, taking as an example a reservoir of local authority, responsible for the system of treatment and distribution of water and sewage of the city of Votuporanga / SP, as well as to present the possible recovery techniques to be applied in each case.

2 METHODOLOGY

2.1 LOCATION OF THE STUDY AREA

In this article, we identified and evaluated the pathologies found in a semi-buried reservoir of reinforced concrete, located in the Municipality of Votuporanga - SP, at Rua Pernambuco, 4313, Patrimônio Novo, with geographical coordinates -20.414106, -49.975030 (Figure 4).

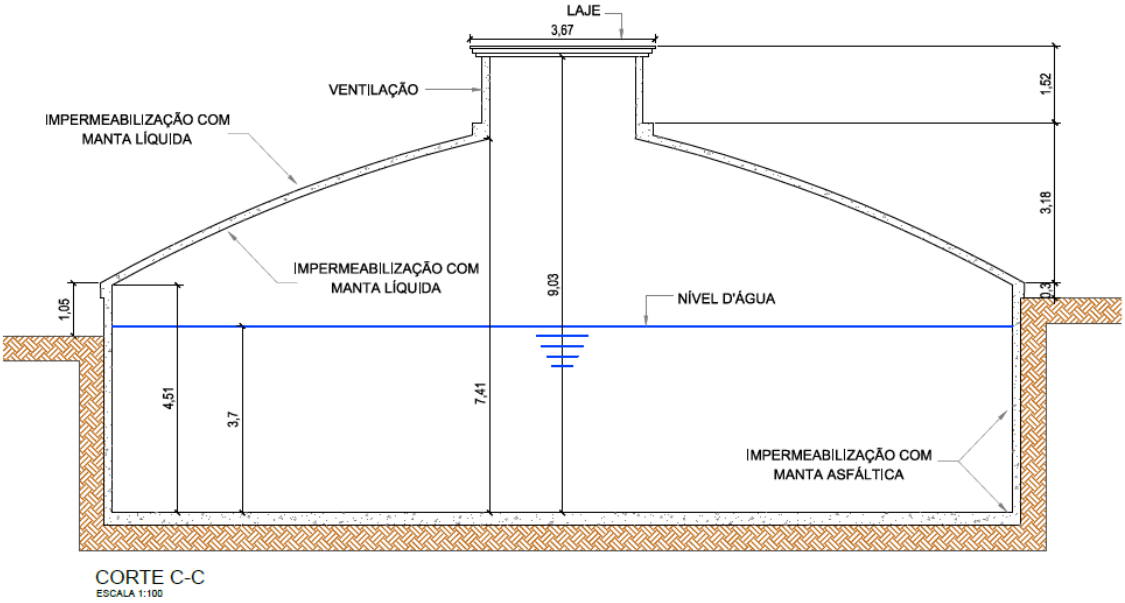
Figure 4 – Aerospace location of the studied reservoir

Source: Google Maps (2023).

2.2 RESERVOIR CHARACTERISTIC

The reservoir studied is of the semi-buried type, built in reinforced concrete, with a capacity of 1000 m³, connected to the suction well. Figure 5 shows the dimensions and geometry of the reservoir studied.

Figure 5 – Dimensions and geometry of the reservoir studied



Source: Own author (2023)

2.3 SELF INSPECTION

Responsible for the administration and distribution of water in the municipality, the local authority received complaints from the population regarding the presence of land in the water, which was stored in the reservoir under study. Due to the various complaints with the same reason, the municipality began the study from inspections in the reservoirs, in order to verify possible problems.

The inspection carried out in the reservoir was classified as "Level 1 Inspection", represented by expeditious analysis of the facts and construction systems inspected, with the identification of their anomalies and apparent failures in the structure.

The Level 1 Inspection is characterized by the isolated or combined verification of the technical conditions of use of maintenance of the building system, according to the Building Maintenance Standard - NBR 5674 of ABNT, respecting the level of inspection adopted, with the classification of the deficiencies found as to the degree of risk it represents in relation to the safety of users, habitability and conservation of the built heritage.

The inspection was carried out by the engineer in charge, together with trainees, and was based on the sensory analysis of the building, according to the Brazilian Standard of Building Inspection – NBR 16747:2020 of ABNT, carried out throughout the external area of the reservoirs.

The inspection precedes the diagnosis of constructive anomalies and maintenance failures that interfere and impair the state of use of the building and its facilities, aiming to verify the aspects of performance, useful life, use and safety that have a direct interface with users.

The survey was made by going through the entire external area of the reservoirs, with caution and attention to perceive all the possible pathologies present and making photographic records to assist in the diagnosis of the manifestations.

After visual inspection, the types of pathologies were identified and a building inspection report was performed.

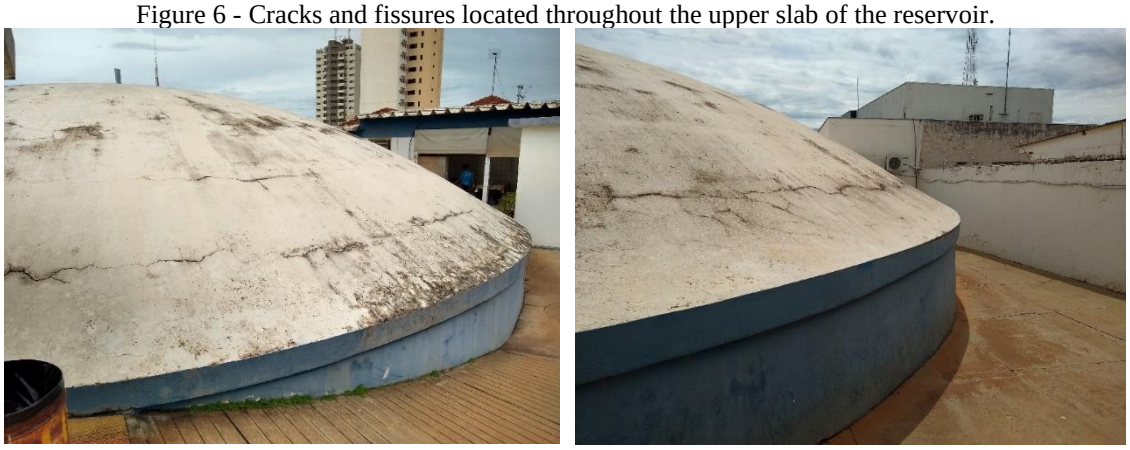
When defining the place of intervention, and which pathologies were found, the maintenance technique to be applied was suggested. Maintenance techniques can vary in complexity, from simpler to more complex approaches, in order to solve the identified problem and also reduce the costs involved.

3 FINDINGS

3.1 IDENTIFICATION OF PATHOLOGIES

After external inspection of the area, a series of pathologies present in the reservoir were identified, such as cracks and cracks, paint deterioration, mold and mold stains and soil repression. Figures 6, 7 and 8 show the pathologies identified.

Figure 6 - Cracks and fissures located throughout the upper slab of the reservoir.

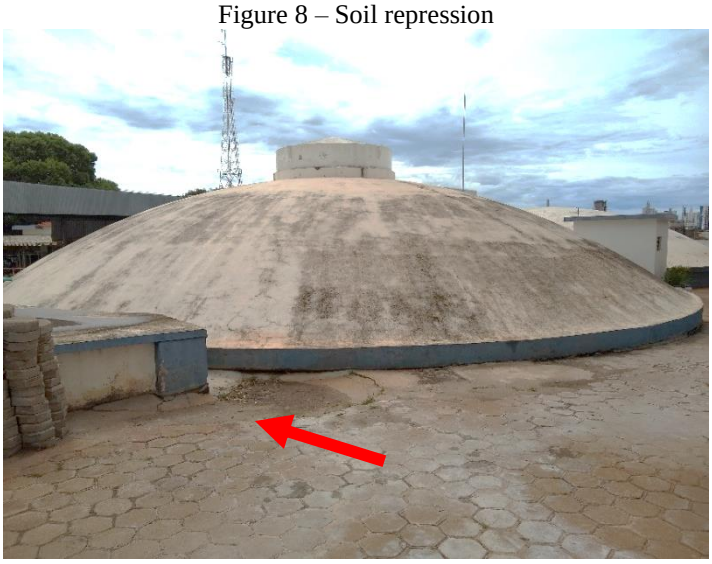


Source: Own author (2023)

Figure 7 – Paint wear and deterioration

Source: Own author (2023)

Figure 8 – Soil repression



Source: Own author (2023)

Analyzing Figure 8, and considering the complaint of the residents regarding the presence of land in the water, it can be inferred that the repression would be responsible for a possible infiltration located in the wall of the reservoir or well, which would justify the passage and entry of land into the reservoir, thus contaminating the water.

In possession of this pre-diagnosis, the local authority hired a company specialized in the treatment of expansion joints, structural injection and application of epoxy blankets and paints to carry out another inspection. At that moment, it was necessary to empty the reservoir, so that another reservoir was left to supply the population, without causing major inconveniences. Once this was done, the engineers of the company contacted, in the presence of the safety engineer of the municipality itself, all equipped with safety equipment, inspected the interior of the reservoir and the suction well.

After inspection, they found that the infiltration originated in a crack present in the wall of the suction well. Thus, even the infiltration not deriving from the semi-buried reservoir, after internal inspection, they noticed the presence of pathologies in the reservoir that could cause future problems, impairing its functioning.

Figure 9 shows the presence of rust and corrosion in the metal pipes. Figure 10 shows the mold and mold stains inside the reservoir and Figure 11 shows the deterioration in waterproofing.

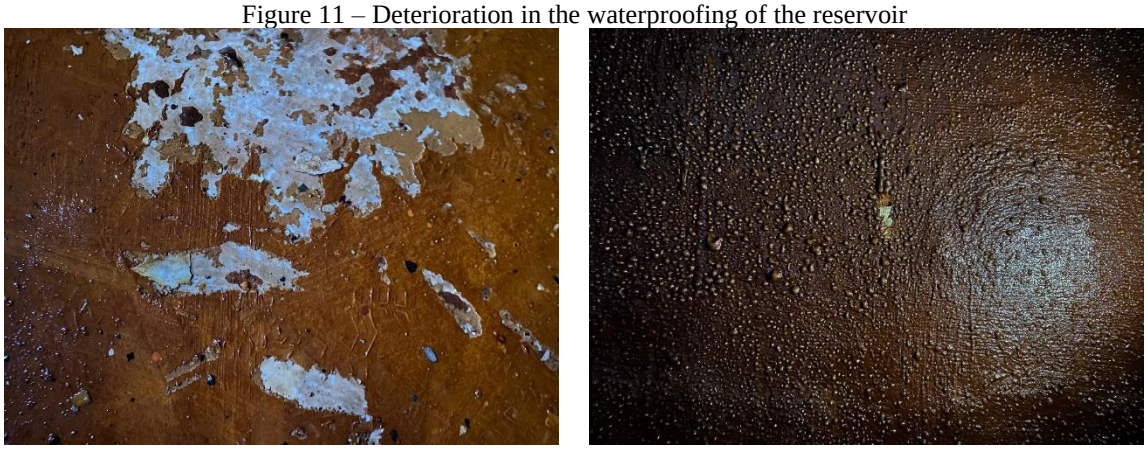
Figure 9 – Rust and corrosion in the metal pipes of the reservoir

Source: Own author (2023)

Figure 10 – Mold and mildew stains inside the reservoir, revealing water accumulation in the vault of the image on the right

Source: Own author (2023)

Figure 11 – Deterioration in the waterproofing of the reservoir



Source: Own author (2023)

3.2 POSSIBLE MAINTENANCE TECHNIQUES AND MATERIALS TO BE EMPLOYED

3.2.1 Cracks and cracks

As previously mentioned, the presence of earth in the water was a consequence of infiltration, through cracks in the wall of the suction well, caused by soil repression.

The first step is to correct this repression, effecting the regularization of the soil. Thus, the saturated soil must be removed and then carried out a landfill using the method of compaction with new soil.

The repair of the cracked regions should be performed by injection of polyurethane resin with the aid of injection pumps. This method presents good penetration for sealing cracks and cracks, recovering the monolithicity of the structure.

The repair of the cracks, because they have larger openings than the cracks, should be done by sealing, applying the *grout* in order to close them.

The *grout* is a mortar paste with fluid consistency used, mainly, to fill empty spaces in places of difficult access, dispensing with the use of vibrators for its densification. (PEREIRA, 2018).

Other striking characteristics of this type of microconcrete are high initial and final strength in a short period and controlled expansion, factors that allow the rapid release of the forms and structures used in its application and the maintenance of the volume of the part / repair after curing (PEREIRA, 2018).

3.2.2 Rust and corrosion of metal pipes

The interconnecting pipe between the semi-buried reservoirs showed pathological manifestations of rust and partial corrosion.

Thus, one should proceed with the cleaning service, using steel brushes or sandpaper and painting with appropriate paints for the reuse of metal elements. This service is performed through sanding to remove all the rust present and, in sequence, made the painting with appropriate methods,

such as galvanized fire painting, which consists of dipping the element in a molten zinc bath at a high temperature, offering a resistant and long-lasting protection.

3.2.3 Mold and mold stains

For the solution of stains and molds manifested in the internal region of the reservoir, it is suggested to perform the cleaning service, proceeding to the washing with nylon brush and with high pressure washer. After drying, a waterproofing agent should be passed for the protection of the repaired areas.

3.2.4 Paint wear and deterioration

In places where the painting has suffered wear and deterioration due to constant contact with water and due to exposure to the elements, cleaning and removal services of the damaged surface can be performed through a scraping and washing process with a steel brush, and then the painting with the use of waterproofing paints, able to withstand that exposure effectively.

3.2.5 Deterioration in waterproofing

In addition to the pathologies mentioned, it was observed that the waterproofing of the semi-buried reservoir was in a deteriorated state, due to the end of the useful life of the product. Thus, it will be necessary to remove the existing asphalt blanket and then apply a new asphalt blanket waterproofing.

4 CONCLUSION

After inspection of the semi-buried reservoir, it was found the presence of cracks, stains and mold, corrosion of pipes, as well as poor painting and waterproofing, often due to carbonation and / or chloride contamination. In addition to these problems of water infiltration, soil repression was also verified. These pathologies are almost always related to executive failures, non-attendance of projects and deficiency in the periodic maintenance system. Thus, it can be highlighted that the lack of control and preventive maintenance for these structures, entail, depending on the state found, high costs with repair and / or recovery of the structure, being essential the knowledge and experience of engineers and surveyors in the identification of pathologies and correct choice of techniques and materials used.

REFERENCES

ALEIXO, T. Identificação e avaliação de patologias em estruturas de concreto armado: um estudo de caso do IFSP -Campus Votuporanga. Trabalho de Conclusão de Curso. Graduação em Engenharia Civil. Instituto Federal de São Paulo. Campus Votuporanga. 2018.

ALEN SOBRINHO, P.; CONTRERA, R.C. Adutoras. Apresentação da disciplina Saneamento II. São Paulo. Escola Politécnica da Universidade de São Paulo. 2016. Disponível em: https://wp.ufpel.edu.br/hugoguedes/files/2019/10/Aula-5-Adutoras.pdf. Acesso em: 20 de maio de 2023.

ANGRILL, S.; FARRENY, R.; GASOL, C.M.; GABARREL, X.; VIÑOLAS, B.; JOSA, A.; RIERADEVALL, J. (2012) Environmental analysis of rainwater harvesting infrastructures in diffuse and compact urban models of Mediterranean climate. The International Journal of Life Cycle Assess, v. 17, p. 25-42.

O Aço Carbono Enferruja? Aparecida Tubos, 14 fev. 2022. Disponível em: http://www.aparecidatubos.com.br/blog/o-aco-carbono-enferruja/. Acessado 15 maio de 2023.

BATISTA, C. Estudo das manifestações patológicas e técnicas de reparo nas estruturas dos reservatórios elevados da cidade de São José de Piranhas/PB. 2022. Trabalho de Conclusão de Curso. Graduação em Engenharia Civil. Instituto Federal de Paraíba. Campus Cajaazeiras. 2022.

Como evitar e remover eflorescências em estruturas de concreto? Disponível em: <https://www.aecweb.com.br/revista/materias/como-evitar-e-remover-eflorescencias-em-estruturas-de-concreto/19336>. Acesso em: 15 jul. 2023.

CRISTINA, I. et al. Impermeabilização com manta asfáltica e solução de patologias causadas por umidade: estudo de caso do reservatório Ceuma V Campus Renascença em São Luís, Ma. Trabalho de Conclusão de Curso. 2020.

DE MARCHI, Gabriela. Estudo de patologia e recuperação de estruturas em concreto armado aparente no IFSP – Campus Votuporanga. Trabalho de Conclusão de Curso. Graduação em Engenharia Civil. Instituto Federal de São Paulo. Campus Votuporanga. 2021.

DO CARMO, Paulo Obregon. Patologia das construções. Santa Maria, Programa de atualização profissional – CREA – RS, 2003.

ENGENHARIA, I. Case de Obra: Injeção de Poliuretano, 2016. Disponível em: <https://www.intech.eng.br/case-de-obra-injecao-de-poliuretano/>. Acesso em: 23 jun. 2023.

FONSECA, A. C. R.; ROCHA, B. B. Principais Manifestações Patológicas Causada por Umidade em Residências: Estudo de Caso. Trabalho de Conclusão de Curso. Graduação em Engenharia Civil. Faculdade UMA de Catalão, 2021.

GENTIL, V. Corrosão. 4. ed. Rio de Janeiro: LTC, 2003.

GONÇALVES, Michele. Manifestações patológicas em reservatórios de água elevados executados em concreto armado. 2008. 111 p. Trabalho de Conclusão de Curso (Engenharia civil) - Universidade Estadual de Feira de Santana, Feira de Santana, 2008.

GUIMARÃES, A. J. A.; CARVALHO, D. F. de; SILVA, L. D. B. Saneamento básico. S. l., 2007, Apostila do Instituto de Tecnologia/Departamento de Engenharia–Universidade Federal Rural do Rio de Janeiro.

IANTAS, L. C. Estudo de caso: análise de patologias estruturais em edificação de gestão pública. Trabalho de Conclusão de Curso. Especialização em Construção de Obras Públicas. Universidade Federal do Paraná. 58p. Curitiba. 2010.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. ISO 8501-1: 2017. Preparação de substrato de aço antes da aplicação de tintas e produtos similares – Avaliação visual de limpeza de superfície – Parte 1: Graus de enferrujamento e graus de preparação de substratos de aço sem pintura e de substratos de aço após remoção total da pintura existente. 2017.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. ISO 8501-2: 2019. Preparação de substrato de aço antes da aplicação de tintas e produtos similares – Avaliação visual de limpeza de superfície – Parte 2: Classes de preparação de substratos de aço previamente revestidos após remoção localizada de revestimentos anteriores. 2019.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. ISO 8501-3: 2020. Preparação de substrato de aço antes da aplicação de tintas e produtos similares – Avaliação visual de limpeza de superfície – Parte 3: Graus de preparação de soldas, arestas e outras áreas com imperfeições superficiais. 2020.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. ISO 8501-4: 2020. Preparação de substrato de aço antes da aplicação de tintas e produtos similares – Avaliação visual de limpeza de superfície – Parte 4: condições iniciais da superfície, graus de preparação e graus de ferrugem em conexão com hidrojateamento. 2020.

LEGER, C. Impermeabilização de reservatórios - Especializada em tratamento de água e efluentes. Disponível em: <https://www.revistatae.com.br/Artigo/652/impermeabilizacao-de-reservatorios>, 2020. Acesso em: 15 maio. 2023.

MARTINS, J. F. A.; FIORITI, C. F. Manifestações patológicas nos sistemas estruturais em Concreto armado de uma edificação pública – núcleo Morumbi da UNESP. 1º Congresso Brasileiro de Patologia das Construções. Foz do Iguaçu-PR, 2014.

MONGE, C. A. A impermeabilização em obras subterrâneas: Conheça o mecanismo de ação da água freática nas estruturas, assim como as estratégias para sua neutralização. Rev. Recuperar. Janeiro / Fevereiro, 2002.

PEREIRA, C. O que é Graute? Escola Engenharia, 2018. Disponível em: https://www.escolaengenharia.com.br/graute/. Acesso em: 26 de maio de 2023.

PIANCASTELLI, Élvio Mosci. Patologia e terapia das estruturas: Intervenções de Reparo (Restaurações). Universidade Federal de Minas Gerais. Minas Gerais, 1997.

REVISTA DIGITAL AECWeb. Patologias do concreto. Disponível em: <https://www.aecweb.com.br/revista/materias/patologias-do-concreto/6160>. Acesso em: 13 mar. 2023.

REVPROL. “Como Consertar Parede Descascando?” - Blog - Revprol. Disponível em: www.revprol.com.br, Julho 2022, www.revprol.com.br/blog/como-consertar-parede-descascando/. Acessado 10 maio 2023.

SANSUY. Conheça 4 tipos de reservatórios de água e quando são usados! Sansuy, 15 jul. 2021. Disponível em: <https://blog.sansuy.com.br/reservatorio-de-agua/>. Acesso em: 13 mar. 2023

SANTANA, G. A. Levantamento de manifestações Patológicas em Reservatório de Concreto Armado no Município de ALEGRETE/RS. Trabalho de Conclusão de Curso. Graduação em Engenharia Civil. Universidade Federal do Pampa. 115p. 2017.

SHIRAKAWA, M.A.; MONTEREIRO, A.B.B.; SELMO, S.M.S.; CINCOTTO, M.A. Identificação de fungos em revestimentos de argamassa com bolor evidente. Anais... SIMPÓSIO BRASILEIRO DE TECNOLOGIA DAS ARGAMASSAS. 1995. Goiânia. p. 402-410.

SILVA, D. H. Recuperação de estruturas de concreto – Corrosão das Armaduras – Estudo levantado no Centro Oeste de Minas Gerais. Revista Científica Multidisciplinar Núcleo do Conhecimento. Ano 03, Ed. 10, Vol. 02, pp. 64-77 Outubro de 2018. ISSN:2448-0959.

SOUZA, V. C. M.; RIPPER, T. Patologia, recuperação e reforço de estruturas de concreto. São Paulo: Pini, 1998.

TECHNIQUES. “Recalques Em Fundações: O Que São E Como Resolver”. Techniques, 8 julho 2020. Disponível em: techniques.com.br/reforco-estrutural-trincas-nas-paredes-rebaixo-de-piso-reforco-estacas-reforco-alicerce/. Acessado 14 maio 2023.

TRICURIOSO. “Como retirar o mofo da parede?” TriCurioso, 27 Set. 2018. Disponível em: www.tricurioso.com/2018/09/27/como-retirar-o-mofo-da-parede/. Acessado 12 Maio 2023.

TINOCO, H. F. F.; MORAIS, A. S. Reservatório sem concreto armado: principais manifestações patológicas, diagnóstico e soluções para reabilitação e reforço. In: CONGRESSO INTERNACIONAL SOBRE PATOLOGIA E RECUPERAÇÃO DE ESTRUTURAS, 9., 2013, João Pessoa. Anais[...]. João Pessoa: CINPAR, 2013. Não paginado.

ZUCHETTI, P. A. B. Patologias da construção civil: investigação patológica em edifício corporativo de administração pública no Vale do Taquari/RS. 2015. Monografia (Graduação em Engenharia Civil) – Universidade do Vale do Taquari - Univates, Lajeado, nov. 2015. Disponível em: http://hdl.handle.net/10737/939.