S&G 17 (2022), pp. 299-313

S&G Journal

REVISTA S&G
ISSN: 1980-5160

PÓS-GRADUAÇÃO DINÂMICA DOS OCEANOS E DA TERRA UFF



# RELATION BETWEEN THE FINDINGS OF THE QUALITY AUDITS AND THE PATHOLOGICAL MANIFESTATIONS IDENTIFIED IN THE POST-CONSTRUCTION PHASE

**Rosana Melo de Lucas Brandão**
rosanabra@gmail.com
Pontifical Catholic University of Goiás – PUC-GO, Goiânia, GO, Brazil

**Jéssica Gabrielle Naves de Abreu**
jessica.g.naves@hotmail.com
Pontifical Catholic University of Goiás – PUC-GO, Goiânia, GO, Brazil

**Marcella Fernandes de Siqueira**
marcellafernandes3996@gmail.com
Pontifical Catholic University of Goiás – PUC-GO, Goiânia, GO, Brazil

## ABSTRACT

Implementing the Quality Management System (QMS) has the following principles: improve the construction processes, reduce production costs, minimize rework, increase productivity, and, consequently, increase profitability and satisfy customers by delivering a quality product. Based on this assumption, the study looks at how the implementation of the QMS affects the post-work, which is justified by the standardization and mastery of procedures by monitoring potential errors that can lead to pathological manifestations. In this context, this study analyzed the findings of the internal and external audits performed during the execution of two developments of collective housing units, executed in the cities of Goiânia and Aparecida de Goiânia, to identify correlations between them and the pathological manifestations identified in the post-construction inspections. The case study and data survey were the methods used. It should be noted that the two surveyed buildings were built with the same construction method. Regarding the audit results, Enterprise A registered 22 more non-conformities (NC) than Enterprise B. During the post-construction phase, Enterprise A was the most compromised with the incidence of pathological manifestations, with 67 more occurrences than Enterprise B.

**Keywords:** QMS; Auditing; Nonconformities; Pathological Manifestation.

PROPPI / DOT
DOI: 10.20985/1980-5160.2022.v17n3.1834

Revista S&G
Volume 17, Número 3, 2022, pp. 299-313
DOI: 10.20985/1980-5160.2022.v17n3.1834

## INTRODUCTION

The NBR ISO 9000 defines quality as the degree to which a set of differentiating properties attributed to an object satisfies requirements, that is, needs or expectations generally expressed in an implicit or mandatory way (ABNT, 2015). According to Nascimento *et al*. (2017), the 2015 version of NBR ISO 9001 leverages certified companies' level of responsibility and systematizes strategic management as a routine, fostering a quality culture linked to the organization's strategies.

According to Fraga (2011), the search for improvement and evolution in the improvement of quality and construction processes has enabled organizations to enhance and adopt new ways and forms of processes in an attempt to transform the way production is carried out, with the main objective of raising the overall level of competitiveness of the economy and improving management processes and the final quality of the work.

The quality system in civil construction started in 1994 with a training program for companies in the industry, with an emphasis on quality management. This program focused mainly on small and medium-sized construction companies. Two years later, in 1996, several organizations started using the QMS, with the Brazilian Program for Quality and Productivity in Housing (PBQP-H) and NBR ISO 9001 standing out.

However, according to Yazigi (2003), the challenge for civil construction companies is greater than the other transformation industries—organizations that initiated the concepts and methodologies of quality. This is due to some characteristics of the construction industry, such as the use of low-skilled labor, the fact that most of the work is performed under bad weather conditions, and the fact that construction is a mobile industry, among other factors.

In this context, Vieira and Oliveira Neto (2019) emphasize that despite the difficulties encountered, quality has played an important role in construction companies, considering that they serve increasingly demanding customers, including in the service after delivery of the works. Companies seek to invest in quality programs because of the competitiveness in the construction segment today and the need for cost reduction and higher productivity.

According to Guimarães (2017), for a company to be efficient in its internal control and perform services with quality, it needs to analyze, demand, and check the internal control. Therefore, these activities can be performed by internal audits and, later, by external audits. The audits' main purpose is to observe and guide the internal processes' functioning, i.e., auditing is seen as a tool that improves, controls, and assesses the performance of the processes and services provided.

In this context, this study analyzed the findings of internal and external audits performed during the execution period of two developments consisting of collective housing units executed in the cities of Goiânia and Aparecida de Goiânia by the same construction company. Subsequently, the results were compared with the pathological manifestations evidenced in the post-construction period, enabling the identification of a correlation between them.

The implementation of the Quality Management System (QMS), in addition to improving the construction processes, aims at producing at lower costs, avoiding rework, and increasing profitability, thus satisfying the customer by delivering a quality product. Therefore, the QMS has been adopted by several construction companies to control their internal processes, especially in identifying non-conformities that affect the buildings' final quality, compromising customer satisfaction and the companies' profitability.

Based on this assumption, this research seeks to observe how QMS implementation can influence post-work, justifying itself by the accuracy of standardization and mastery of procedures to obtain better results and control possible errors that lead to non-compliance. This can generate pathological manifestations in the post-work and identify whether the findings evidenced in an audit can predict the final quality of housing units.

## THEORETICAL FOUNDATION

### Requirements of NBR ISO 9001: 2015

From August to September 2015, NBR ISO 9001 circulated for national consultation.

It is worth emphasizing that the aforementioned standard was prepared by the Brazilian Quality Committee (CB-025) and the Quality Systems Study Committee (ABNT, 2015).

Under the NBR ISO 9001 (ABNT, 2015), adopting a quality management system is a strategy for an organization that can help improve its performance and support sustainable development actions. Companies that adopt a QMS have the following benefits:

Ability to make available products and services that meet consumer and employable regulatory requirements;

Provision of opportunities to enhance customer satisfaction;

Dealing with risks and opportunities related to the context and objectives of the organization; and

Ability to demonstrate compliance with standardized requirements in the quality management system.

Furthermore, NBR ISO 9001 (ABNT, 2015) is based on the quality management specifications contained in ABNT NBR ISO 9000, more precisely on the statements of principles and the relevance they have for organizations, including examples of benefits and actions to improve their performance. In this context, the quality management principles are customer focus, leadership, people engagement, process approach, improvement, evidence-based decision-making, and relationship management.

According to Altoumian, Souza, and Lapa (2020), PDCA is an acronym derived from the English language, meaning plan (plan), do (execute), check (verify), and act (adjust). The authors emphasize that this is one of the main tools used in quality management support. In short, this cycle aims to organize the organization's actions to increase the possibility of achieving results through the structuring of plans, correct application, and supervision of improvement indicators. As a result, Campos (1996) defines the PDCA cycle or improvement method as the procedure management process used to achieve the goals established for business systems. In this sense, the PDCA cycle is "a way to achieve a goal."

Kanri (1944) understands that any organization would have its continuity compromised if its guidelines were undefined. PDCA can be defined as follows: P - Implementation of directives at all administrative levels; D - Performance of necessary, priority, and efficient actions; C - Follow up of results and development of measures; and A - Analysis of the difference between goals and results, the conclusion of the causes of the problem, and orientation of corrective actions.

The NBR ISO 9001 standard emphasizes that only correction and continuous improvement used as a form of QMS improvement may not meet an organization's future needs and expectations given the progressively dynamic and complex environment in which they are inserted. Disruptive change, innovation, and reorganization are measures considered a solution to this demand. It is worth emphasizing that it is essential to understand and manage the correlation between the processes, treating them as a system so that an organization achieves effectiveness and efficiency in the planned results (ABNT, 2015).

Sá *et al*. (2015) clarify that the NBR ISO 9001 presents the seven principles of quality management as essential requirements, cited in ISO 9000, using a statement of the principle, a logical justification, the advantages of its use, and the conduct to be adopted. The seven requirements established by NBR ISO 9001 (ABNT, 2015) are the context of the organization, leadership, planning, support, operation, performance evaluation, and improvement.

**Brazilian Quality and Productivity Program at Habitat**

According to Vieira and Neto (2019), the Brazilian Habitat Quality and Productivity Program (PBQP-H) is a Federal Government tool for structuring the civil construction sector through quality improvement. This structuring comes through the qualification of construction companies, labor, productivity, services, suppliers of materials and equipment, and standardization, among others.

The PBQP-H was created by the Minister of Planning and Budget through Ordinance No. 134, December 18, 1998, as a complement to the Brazilian Program for Quality and Productivity (PBQP). The Ordinance states that the PBQP-H's main goals are to support and promote quality and productivity in the housing construction sector to increase the competitiveness of quality goods and services produced by it.

According to Januzzi (2010), the PBQP-H is based on the ISO 9000 standard; thus, since its creation, it has undergone periodic innovation to accompany the revisions of ISO 9001. Therefore, the PBQP-H aims to guide organizations regarding the performance of quality management, and with this, organizations will have more productivity, organization, and standardization and, in the end, deliver a product with better quality to the customer.

According to the PBQP-H website (2022), joining the program is voluntary, and there are three assessment and qualification systems, namely: the Conformity Assessment System for Civil Construction Service and Construction Work Companies (SiAC); NBR 15575, the so-called Performance Standard; the Qualification System for Companies that Manufacture Materials, Components, and Construction Systems (SiMAC); and the National Technical Assessment System for Innovative Products and Conventional Systems (SiNAT).

SiAC is divided into levels "A" and "B." The main difference between them is the number of mandatory requirements and the minimum quantity of controlled services and materials. To meet the requirements at level B, 70% of the goods, 40% of the services, and 50% of the materials must be present. However, level A is necessary for the company to prove compliance with all requirements. The requirements that should be implemented at level A are as follows: actions to address risks and opportunities; environments for operating processes; measurement traceability; planning the work execution; communication with customers; critical analysis of requirements related to the work; changes to requirements related to the work; project inputs; project

Revista S&G
Volume 17, Número 3, 2022, pp. 299-313
DOI: 10.20985/1980-5160.2022.v17n3.1834

control; project outputs; project change; supplier evaluation process; site equipment rental; properties owned by customers and site suppliers; post-delivery activities; site release; analysis and evaluation; and continuous improvement (Albuquerque, 2022).

### Internal and external quality audits

According to the Standard Guidelines for Quality or Environmental Management System Audits, NBR ISO 19011, audits are systematic, independent, and documented processes aimed at obtaining evidence and assessing whether the results of an organization's quality or environmental policy are satisfactory (ABNT, 2002).

Moreover, according to the terms of NBR ISO 9000 (ABNT, 2015), audits aim to determine the degree of compliance with the regulatory QMS requirements, and the audit findings should be used to evaluate their effectiveness and as a tool for improvement opportunities. According to Biagio (2013), the principles of auditing are composed of evaluating the efficiency and adequacy of the quality system, a survey of improvement points, maintenance of the active system, and management assistance. Still, according to Biagio (2013), the audit program's result is achieved by combining these four principles.

Complementing Biagio's (2013) understanding, the NBR ISO 19011 (ABNT, 2018) emphasizes that audits have efficiency as their primary goal in support of policies and management control, bringing information that clarifies where the organization is lacking so that quality in services can be achieved. Still, the aforementioned standard indicates the principles that every audit must meet: integrity; fair presentation; due professional care; confidentiality; independence; evidence-based approaches; and risk-based approaches.

Audits are classified as follows: internal audits (Part 1), conducted by a team of auditors from the organization itself; external audits (Part 2), conducted by an external auditor who has no functional link with the company; and certification and recertification audits (Part 3), aimed at verifying that the organization meets all the standards' requirements (ABNT, 2018).

### Post-work professional responsibilities

Pelacani (2010) understands that pathology is the diagnosis of the causes of the failures in buildings, determining the evolution procedures, how they arise, forms of prevention, and repair. Thus, it is defined as the science that seeks to know the failures of the elements of a building in general. The pathological failures caused in the execution phase can be due to socio-economic dysfunctions that cause a lack of properly qualified labor.

According to the standard of the Brazilian Institute of Evaluations and Expertise (IBAPE), the technical faults and quality of the building may cause nonconformities, and they may not correspond to the compliance criteria stipulated for the building systems and tools used, specifically: the manufacturer's information and suggestions, technical manuals, projects, and descriptive memorials. Thus, IBAPE (2019) classifies pathological manifestations as:

Endogenous: failure arising from the building itself, which may be caused by the project, material, or execution; and

Exogenous: failure originating from elements external to the building, caused by external agents.

According to Pinheiro *et al*. (2018), the origin of pathologies may be related to flaws in the execution or design and not only to the lack of maintenance of the building. However, pathologies must be noticed in advance so that appropriate action can be taken.

Meirelles (1996) esclarece que quando o engenheiro ou arquiteto constrói algo, ele responde pelos defeitos que a construção manifestar enquanto estiver no prazo de garantia de cinco anos, nos termos do artigo 618 do Código Civil Brasileiro, independentemente se tiver construído com um contrato de empreitada ou administração.

Still, according to Meirelles (1996), if a building collapses as a result of a technical error, causing material destruction, damage to third parties, and injuries to several people, four types of liability may arise from repair of the property damage resulting from civil liability, criminal penalties specified in the Penal Code, administrative liability, and compensation to employees in the case of accidents at work.

Regarding consumers, article 12 of the Consumer Law Code (Brazil, 1990) states that professionals are liable for damages caused to them due to faults in the project design or work execution or inadequate or insufficient information about the maintenance and use of the building. This code also states that the deadline to formalize the complaint expires after ninety days. When the defect is apparent, the deadline starts with the effective delivery of the property. In the case of hidden defects, the period begins when the defect is identified.

## METHODOLOGY

According to Gil (1946), research can be defined as a rational and detailed process aimed at presenting solutions to

problems that are proposed. The case study is based on an in-depth and detailed analysis of a specific object, so as to offer comprehensive knowledge about the researched subject. In this context, this research used two buildings executed by the same construction company as a case study to identify whether there is a relationship between the findings of the quality audits and the pathological manifestations identified in the post-construction phase.

It is worth mentioning that, for this research, the authorization of the construction company's managers responsible for the data that is the object of the study was requested with the commitment to maintain confidentiality about the company's name and the projects to be studied, as well as about any administrative processes that allow identifying the company. The duly signed consent form is in the authors' possession; however, it cannot be presented to guarantee confidentiality.

**Characterization of the company and the enterprises that are the object of the case study**

The company in question is a Brazilian construction company founded in the state of Minas Gerais that has as its main activity executing enterprises for the middle and lower classes, currently through the "*Casa Verde e Amarela*" program. It has level "A" PBQP-H and QMS certifications by the NBR ISO 9001:2015 standard.

The two developments—case study objects—were built using the same construction method, i.e., a self-supporting structure. The foundation was executed with staked foundations and propeller-type piles. The location of the rooms is carried out directly on the slab foundation. It is worth remembering that the same forms are used for first-floor apartments and other types. The walls are concreted and have a structural function; the solid slab is concreted together with the walls.

The enterprises' floors were finished with ceramic tile in all apartments on the first floor; on the other floors, ceramic tile was used only in the kitchen and bathroom, and laminate flooring was used in the living room and bedrooms. The walls are covered with floor-to-ceiling tiles in the bathroom boxes, while the other bathroom walls, the kitchen wall where the sink and stove are located, and the service area were tiled up to a height of 1.50 m. The rest of the walls are finished with running plaster and acrylic paint. The window frames are made of white anodized aluminum, and the doors are made of wood.

In addition, the common areas of the developments include a reception room, a gourmet barbecue, children and adult swimming pools, a pet park, and a playground, in addition to bicycle racks distributed in the enterprises' areas, a sentry box, trash cans, changing rooms, an administration room, a telecommunications room, and a liquefied petroleum gas (LPG) central office.

Condominium A consists of 212 apartments divided into 13 blocks, 12 of which have four floors and one has five. On the first floor are 26 apartments with a private area of 48 m², ten adaptable for the disabled with 41.50 m², and 176 common apartments with a private area of 39.10 m². Construction started in October 2020 and will be completed in February 2022. Condominium B consists of 240 apartments in 12 blocks of five floors, with 232 units with two bedrooms and eight with two bedrooms reversible to one bedroom for disabled people. Both typologies have 39.3 m² of internal area, with 31 units with uncovered private spaces in different areas. This enterprise's construction started in August 2020 and was finished in April 2022.

Internal and external audits are carried out periodically to ensure the quality of the work and maintain the certifications obtained. The communication of the dates to the managers responsible for the work is optional; that is, it is possible to carry out audits without prior communication. The internal audits are carried out by a construction company team, which audits all the construction sites in the state, ensuring impartiality and standardization of procedures. However, the external audits, which renew or maintain the certifications, are performed by independent certifying bodies; currently, these audits are performed by Bureau Veritas Certification.

During the audits, the non-conformities are registered in a specific report. Subsequently, action plans to treat the non-conformities are opened. The identification of corrections, causes, and corrective actions are, in their great majority, the responsibility of the employee responsible for the quality area of the work, in partnership with the engineer and other team members. Then, in the next visit or internal audit carried out on site, the nonconforming items previously identified are checked to certify that the problem has been solved. **Figure 1** shows a scheme with the main steps of the audits.

During the finalization of the blocks, they are passed on to the company's technical assistance (TA), which is responsible for the final inspection. All non-conformities and defects found are inserted in a report. With this, the construction team proceeds with the necessary repairs. Afterward, a second inspection is carried out to verify whether all the pending issues observed have been solved; if so, the TA receives the block, and it becomes their responsibility. The main stages and the activities performed by the TA are shown in **Figure 2**.

Revista S&G
Volume 17, Número 3, 2022, pp. 299-313
DOI: 10.20985/1980-5160.2022.v17n3.1834

### Analysis of records and documents

The data and records used were obtained with the technical assistance of the construction company, and the photographic documents are the responsibility of the researchers. It is also worth mentioning that, during the research period, the condominiums were not inhabited. In addition, data from audits carried out in the two condominiums were also used; in this sense, enterprise A was audited between January and December 2021, while enterprise B had its audits carried out between January and October 2021. All documents were received and analyzed between August and October 2022.

## RESULTS AND DISCUSSION

Having as a reference the objective of this research, next the results will be presented, with which a comparison will be made, first, of the findings of the internal and external audits in the two enterprises under study, and then of the pathological manifestations identified in the post-work of both condominiums. Finally, the correlation between all the data will be analyzed to identify whether the QMS implementation contributes to reducing pathological manifestations.

### Audit results

During the audit process, approximately 34 items are verified at the construction site, including internal and external documentation, employee training, construction equipment, material storage, the execution of services in the field, and activities involving the environment and occupational safety. The audit starts with a score of 100, and as nonconformities are found, the weights stipulated for each normative requirement are deducted, considering their influence on the final product.

First, Enterprise A was analyzed, and with it, the audits were analyzed between January and December 2021, when 11 internal audits and one recertification audit were performed, totaling 12. **Figure 3** shows the results of these audits. On average, 35 items were verified per audit, giving the enterprise an average score of 84.5 and evidencing 30 nonconformities.

About the nonconformities cited in **Figure 3**, the following nonconforming items were identified: traceability of measurement, training, proof of competence, internal verification of materials, and a master list of projects and documents, all from requirement 7 of NBR ISO 9001 (2015). The traceability of the launching of the self-compacting concrete, mortar test validation, materials storage, filling out the service verification form (FVS), execution control, descriptive memorials, concrete reports, making and updating the minutes of the planning meeting, and grout test validation are activities included in requirement 8 of the standard above.

It is worth noting that the lack of or incorrect filling out of the FVS resulted in six nonconformities, and the execution control had recurring nonconformities in four audits, while the measurement traceability and the storage of materials were pointed out three times. Meeting minutes, concrete traceability, training, and the master list of projects and documents resulted from two nonconformities each (**Figure 4**).

Regarding Enterprise B, audits were carried out between January and October 2021, and in all, only eight nonconfor-


**Figure 1.** Internal and External audit steps
Source: The authors (2022)

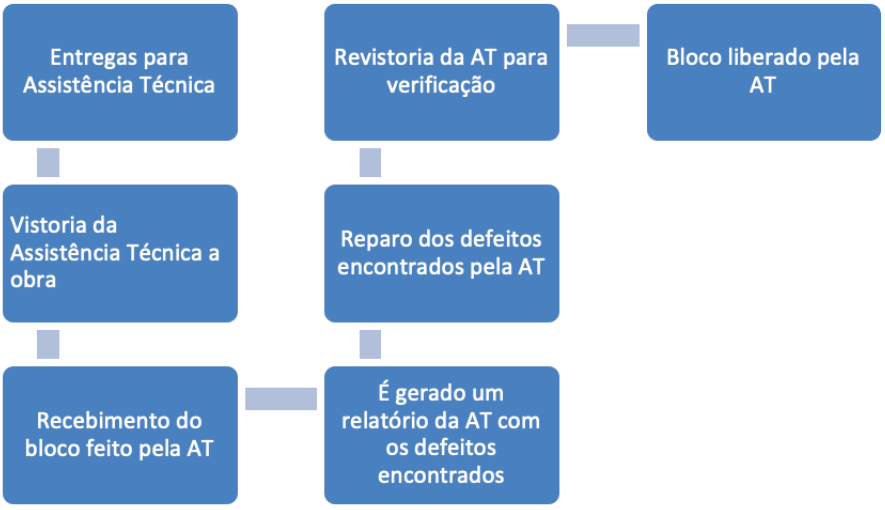



**Figure 2.** Delivery stages for Technical Assistance
Source: The authors (2022)

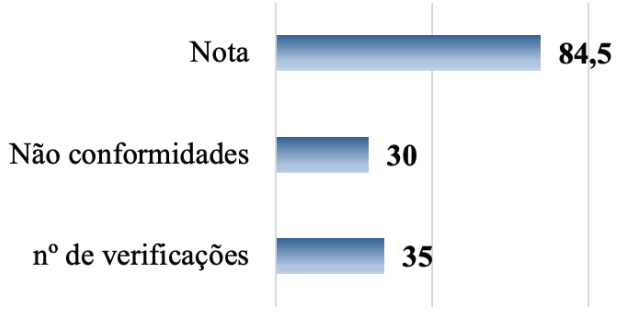



**Figure 3.** Results of the audits of Enterprise A
Legend: Grade 84.5; Nonconformities 30; No. of verifications 35
Source: The authors (2022)

mities were detected during the entire course of construction, totaling an average score of 94.4, as seen in **Figure 5**. It can be seen that, compared to Enterprise A (**Figure 3**), Enterprise B scored 11.17% higher and had 3.75 fewer nonconformities.

The nonconformities found in Enterprise B include the stamping of materials and services, evidenced twice; the failure to prepare meeting minutes, execution control, and concrete reports, all from Item 8 (Operation of PBQP-H), had one occurrence. Nonconformities in training were also detected, with two NCs and one failure in the master list of requirement 7 (Support); lastly, a nonconformity was registered in the company's Sustainability Policy corresponding to requirement 5 (Leadership), as seen in **Figure 6**.

**Pathological manifestations identified in the post-work period**

During the handover of the enterprises, the team responsible for the post-work carried out inspections of all the systems, including public equipment and infrastructure, when some pathological manifestations were identified and duly registered. Besides the visual observation, some equipment is also used in the inspection phase, such as squares, level rulers, and rubber hammers. All evidence is entered into their application, including photographic documents.

The analysis of the pathological manifestations identified in buildings A and B to enable the presentation of the results was grouped into four categories: structure and infrastructure, frames, installations (electrical and plumbing), and finishing. Enterprise A showed the incidence of 17 pathological manifestations identified in the structure and infrastructure, 42 in the frames, 43 in the electrical and plumbing installations, and 162 in the finishing, as shown in **Figure 7**.

Revista S&G
Volume 17, Número 3, 2022, pp. 299-313
DOI: 10.20985/1980-5160.2022.v17n3.1834

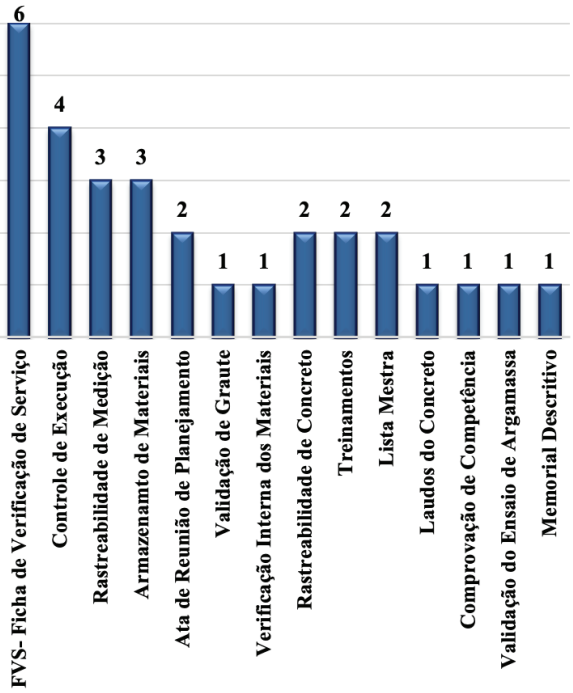



**Figure 4.** Identification of non-conformities in the audits of Enterprise A

Legend: FVS - Service Verification Sheet; Execution Control; Measurement Traceability; Material Storage; Planning Meeting Minutes; Grout Validation; Internal Verification of Materials; Concrete Traceability; Training; Master List; Concrete Certificates; Proof of Competence; Mortar Test Validation; Descriptive Memorial

Source: The authors (2022)

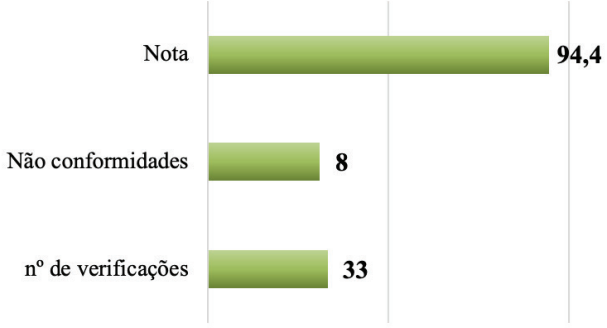



**Figure 5.** Results of audits of enterprise B

Legend: Grade 94.4; Nonconformities 8; No. of verifications 33

Source: The authors (2022)

**Figure 7** shows that the group with the highest occurrence of pathological manifestations was the finishing group, with 162 occurrences. Of these, 91 paint finish incidents are highlighted (**Figures 8** and **9**), followed by cracked or broken ceramic tiles or failure in the laying process with 18 occurrences (**Figures 10** and **11**) and lack of grouting with 15. The other occurrences in the finishing group of Enterprise A are lack of baseboard with nine occurrences, broken sills with six, damaged kitchen countertops with five, failure in the finish of the angles with four, failure in the finish of the shafts with four, and only one occurrence of a defect in the laminate floor.

As for the group of electrical and plumbing installations - the second group with the most occurrences, with 43 records (**Figure 7**), problems in the finishing of electrical modules showed 15 occurrences, followed by evidence of failure in the gas piping finishing with 13 occurrences, leaks in the water piping with ten records, identification of pathological manifestation in the installation of the measurement board with three pieces of evidence, and inadequate finishing of the bathroom and kitchen sink piping with two occurrences.

The frame group had 42 pathological manifestations in Enterprise A (**Figure 7**). The occurrences included 16 dama-

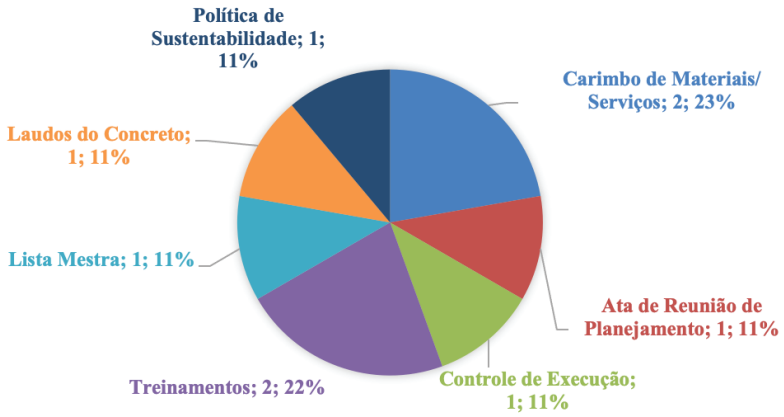



**Figure 6.** Number of nonconformities in Enterprise B
Source: The authors (2022)

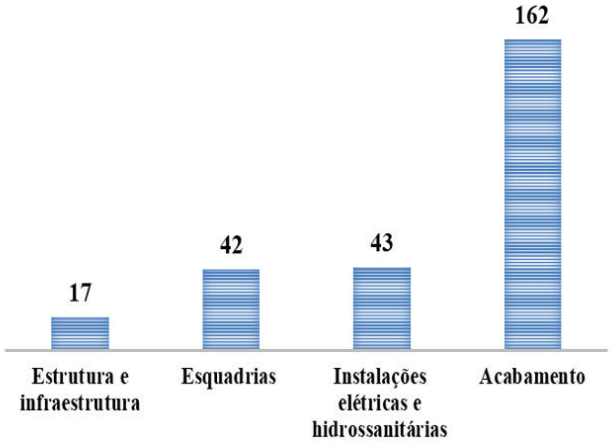



**Figure 7.** Quantities of pathological manifestations identified in enterprise A
Legend: Structure and infrastructure; Frames; Electrical and plumbing installations; Finishing
Source: The authors (2022)

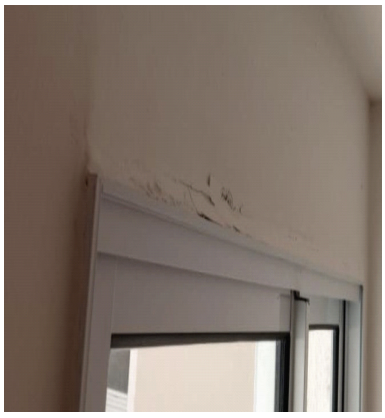
ged doors, the most frequent pathological manifestation, followed by the compromised sealing of windows and windows with defects in the opening limiter with ten occurrences each, five records of defects in door latches and locks, and only one occurrence of failure in the sealing of a trapdoor.

**Figure 7** shows that the structure and infrastructure group had elements compromised with 17 pathological manifestations. It is worth emphasizing that the buildings under analysis were built with reinforced concrete walls and slabs, as mentioned in the methodology. In this context, the pathological manifestations identified with the highest incidence were infiltrations, with eight occurrences; misalignment in the squareness of the doorway, with 5; and cracks, with four records.

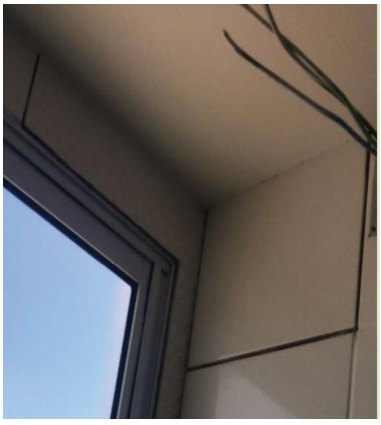
The pathological manifestations identified in Enterprise B were also organized into groups and the results are shown in **Figure 12**. Twenty-five pathological manifestations were registered in the structure and infrastructure group, 36 in the frames group, 21 in the electrical and plumbing installations group, and 115 in the finishing group. Only the structure and infrastructure group had an increase in occurrences with an index of 47.06%. The others showed a decrease compared to Enterprise A, with the frames group with 14.29%, electrical and plumbing installations with 51.16%, and the finishing group with a decrease of 29.01%, compared to enterprise A.

As evidenced in **Figure 12**, the highest occurrence of pathological manifestations was identified in the finishing system. The main causes were 44 occurrences of cracked (**Figure 13**), broken (**Figure 14**), or incorrectly laid ceramic pieces (hollow pieces), 29 occurrences of problems with the paint (**Figure 15**), 28 occurrences of lack of grouting (**Figure 16**), ten events of defects in the laminate flooring, and errors in the trim of the ceramic floor and the laying of the kitchen countertops, with two occurrences each.

Revista S&G
Volume 17, Número 3, 2022, pp. 299-313
DOI: 10.20985/1980-5160.2022.v17n3.1834



**Figures 8 and 9.** Pathological manifestations incidental to the painting of enterprise A
Source: The authors (2022)



**Figures 10 and 11.** Pathological manifestations incidental to the ceramic coatings of enterprise A
Source: The authors (2022)

## Comparison of found results

In the structure and infrastructure group, the manifestation of enterprise B is the only one that showed more occurrences than enterprise A (**Figures 7** and **12**). Infiltrations with 17 records and cracks with 08 occurrences were the pathological manifestations identified in this group.

As for the frames group, the following pathological manifestations were identified: 18 damaged doors, 10 window seals, 5 locks and latches, and 3 window limiters. In the electrical and plumbing installations group, the pathological manifestations identified in the post-construction inspections at Enterprise B were the finishing of electrical modules with five occurrences, the finishing of gas pipes with six, and water leakage with ten.

In addition to the records of evidence regarding the number of failures, enterprises A and B had pathological manifestations classified as low, medium, and high complexity by the professionals who performed the post-construction inspections. The occurrences classified as low complexity can be treated during the post-construction inspection, thus preventing them from being reanalyzed at the next inspection; however, even when the problem is solved, they are duly registered. As a result, other pathological manifestations classified as medium or high complexity necessitate more time for treatment. Thus, they must be checked again in the following inspection, with another failure in the correction eventually occurring. Only after the post-construction team approves the enterprise are the inspections finalized.

**Figures 17** and **18** show the number of pathological manifestations identified during post-construction inspections in each building, subdivided into low complexity and other complexities. The numbers show that in Enterprise A, 29 occurrences of low-complexity pathological manifestations were recorded, and in Enterprise B, they totaled 69 records. However, the sum of the pathological manifestations identified as “other complexities” (medium and high) in Enterprise A totaled 235 occurrences. In Enterprise B, there were 128, i.e., Enterprise A had 83.59% more pathological manifestations than Enterprise B, a worrisome result considering the severity of the occurrences.

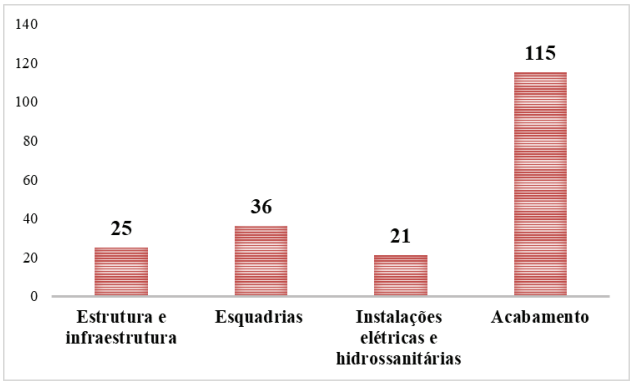



**Figure 12.** Numbers of pathological manifestations found in enterprise B
Legend: Structure and infrastructure; Frames; Electrical and plumbing installations; Finishing
Source: The authors (2022)

**Figures 13 and 14.** Pathological manifestations incidental to the ceramic coatings of enterprise B
Source: The authors (2022)

Analyzing the pathological manifestations of medium and high complexity, identified in **Figures 17** and **18**, as "other complexities," only in the structures group did enterprise B evidence 21.43% more occurrences than enterprise A. For the other groups, the following decreases were evident: frames with 35.51%, installations with 62.16%, and finishing with 50.34%.

Firstly, the company adheres to the lean construction methodology, employing planning techniques that allow a four-story block to be completed and delivered to technical assistance in 62 days. Based on this observation, it is worth pointing out that Enterprise B followed this deadline assiduously, thus resulting in the non-treatment of cracks since, after only two months, the building would not have moved and dilated completely. Therefore, as a strategic decision aligned with the technical assistance, the Enterprise B team decided to deliver the apartments with the initial cracks and treat them at the end of the work before delivering them to the clients. This way, the technical assistance pointed out the cracks, registering and mapping them.

As for Enterprise A, the expected deadline of 62 days for delivery of the units was not met according to the documents analyzed. Due to this, it was possible to proceed with the delivery of the units with some movement and dilatation cracks treated since the four-story blocks were delivered late.

Given this finding, the considerations regarding the authors' perception of the influence of the QMS implementation in the works, especially on the audit results, will be presented to identify their correlation with the pathological manifestations identified in the technical assistance stage. Therefore, a rereading of the main results becomes pertinent to compare the scores of both enterprises, the number of nonconformities (NC) found, and the number of pathological manifestations of low complexity (MPb) and the other pathologies (MPd) evidenced in the post-construction phase. All results are summarized in **Figure 19**.

In this way, the nonconformities of the enterprise that presented lower audit scores and a greater number of problems detected by technical assistance led to the finding that the QMS played a key role in the post-construction phase of the condominium. This means that if this sector had not intervened in the construction stage, inspecting processes and procedures to charge the team to correct some noncon-

Revista S&G
Volume 17, Número 3, 2022, pp. 299-313
DOI: 10.20985/1980-5160.2022.v17n3.1834

**Figure 15.** Pathological manifestations incident in the painting of enterprise B
Source: The authors (2022)

**Figure 16.** Lack of grout found in surveys at enterprise B
Source: The authors (2022)

formities during execution, the number of pathologies evidenced in the delivery of the blocks would have been higher. In this sense, Enterprise A showed the highest number of nonconformities and the highest number of pathological manifestations of medium and high complexity (**Figure 19**).

It is worth emphasizing that the works were executed almost simultaneously, besides the similarity of the projects, construction methods, and the same suppliers. In addition, the audits were performed by the same team of quality professionals. In this context, the only unusual variable in the two enterprises was the operational teams in engineering and raw labor. Better team management and commitment to following the company's procedures may have been positive and decisive in the quality of the products delivered.

## CONCLUSIONS

This study aimed to observe how the implementation of the QMS can influence the post-construction phase, justified by the need to standardize and master procedures to obtain better results and control possible errors that lead to non-conformities. This could generate pathological manifestations in the post-construction phase and identify if the findings evidenced in an audit can anticipate the final quality of the housing units.

Then, aiming to verify the possible relationship between the findings of quality audits and the pathological manifestations evidenced in the post-construction phase, two enterprises built by the same construction company, audited by the same QMS team, and with the same construction process and similar characteristics were the object of this case study.

Thus, aiming to verify the possible relationship between the findings of quality audits and the pathological manifestations found in the post-construction phase, two enterprises built by the same construction company, audited by the same QMS team, and with the same construction process and similar characteristics were the object of this case study.

Therefore, from the research carried out, the findings evidenced in an audit can anticipate the final quality of the housing units since the inspections made by the QMS auditors show flaws committed by the team. This allows the team to remedy the deficiencies found during the execution period, which has influenced the reduction of pathologies found in the delivery stage of the apartments.

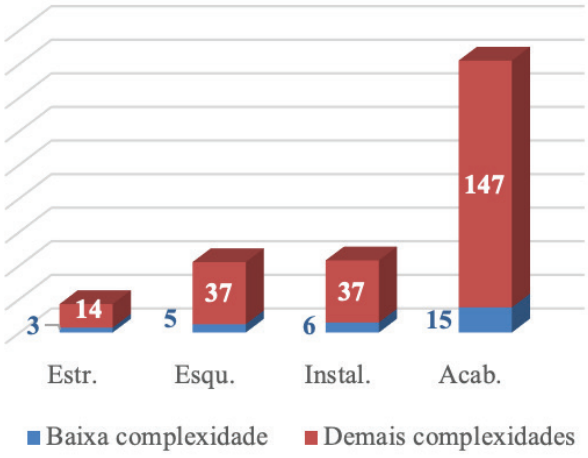



**Figure 17.** The number of pathological manifestations identified in enterprise A
Legend: Structure; Frames; Installation; Finishing; Low complexity; Other complexities
Source: The authors (2022)

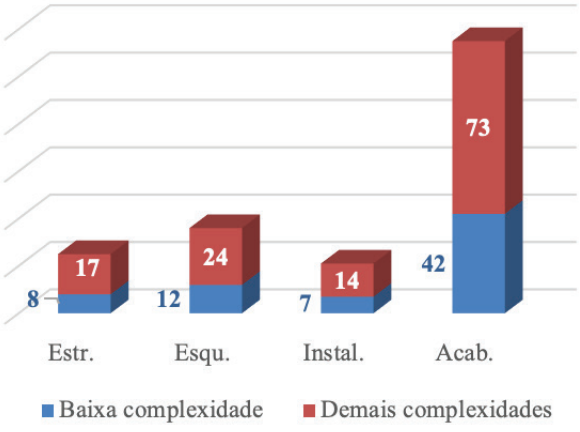



**Figure 18.** The number of pathological manifestations identified in enterprise B
Legend: Structure; Frames; Installation; Finishing; Low complexity; Other complexities
Source: The authors (2022)

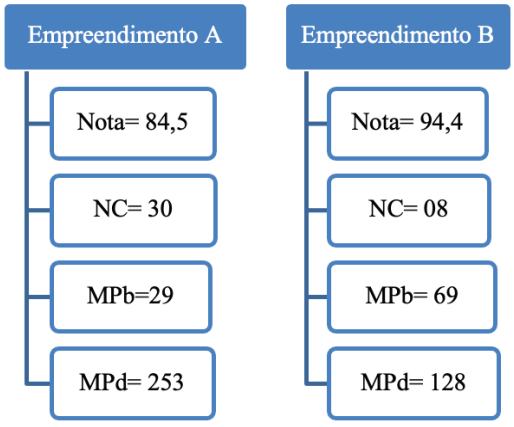



**Figure 19.** Summary of results identified in Enterprises A and B
Source: The authors (2022)

Revista S&G
Volume 17, Número 3, 2022, pp. 299-313
DOI: 10.20985/1980-5160.2022.v17n3.1834

The aforementioned conclusion can be based on the numbers found in both enterprises and by studying other hypotheses that were discarded as the research developed, leading the authors to reaffirm that there is a correlation between the findings of internal and external audits and the quality of the product received after the project.

Therefore, the phrase: "We only do better what we repeatedly insist on improving. The search for excellence should not be a goal, but a habit" is still relevant today.

## REFERENCES

Albuquerque, A. (2022), 'As diferenças entre níveis do PBQP-H: Nível A e B', blog post, *Templum*, disponível em: <https://certificacaoiso.com.br/as-diferencas-entre-o-nivel-b-e-o-nivel-a-do-pbqp-h/> (acesso em: maio de 2022)

Altounian, C.S., Souza, D.L. & Lapa, L.R.G. (2020), *Gestão e governança pública para resultados*, 2ª ed, Fórum, Belo Horizonte.

Associação Brasileira de Normas Técnicas (2000), *Gestão para o sucesso sustentado de uma organização*, ABNT, NBR ISO 9004, Rio de Janeiro.

Associação Brasileira de Normas Técnicas (2007), *Avaliação de conformidades – Requisitos para organismos que fornecem auditoria e certificação de sistemas de gestão*, NBR ISO/IEC 17021, ABNT, Rio de Janeiro.

Associação Brasileira de Normas Técnicas (2015), *Sistemas de gestão da qualidade – fundamentos e vocabulários*, NBR ISO 9000, ABNT, Rio de Janeiro.

Associação Brasileira de Normas Técnicas (2015), *Sistemas de gestão da qualidade – requisitos*, NBR ISO 9001, ABNT, Rio de Janeiro.

Associação Brasileira de Normas Técnicas (2018), *Diretrizes para auditoria de sistema de gestão*, NBR ISO 19011, ABNT, Rio de Janeiro.

Biagio, L.A. (2013), *Manual de auditoria de sistema da qualidade*, n.b., n.p.

Brasil (1990), Presidência da República, Lei nº. 8.078, de 11 de setembro de 1990, Dispõe sobre a proteção do consumidor e dá outras providências, Presidência da República, Brasília, DF, disponível em: <http://www.planalto.gov.br/ccivil_03/Leis/L8078.htm> (acesso em: 15 maio 2022)

Brasil (2018), Portaria nº 383, de 14 de junho de 2018, Dispõe sobre o Sistema de Avaliação da Conformidade de Empresas de Serviços e Obras da Construção Civil – SiAC, Diário Oficial da União, Brasília, DF, seção 1.

Brasil (2020), Ministério do Desenvolvimento Regional, *Programa Brasileiro da Qualidade e da Produtividade do Habitat – PBQP-H,* Ministério do Desenvolvimento Regional, n.p., consult. Março de 2022, <https://www.gov.br/mdr/pt-br/assuntos/habitacao/pbqp-h/o-pbpq-h>.

Campos, W.A. (2015), *ISO 9001: 2015 - Princípios e Requisitos*, n.p., disponível em: <https://www.academia.edu/30652944/ISO_9001_2015> (acesso em: 17 abril 2022)

Domingues, P. & Fonseca, L. (2016), Auditar a norma ISO 9001:2015 - uma perspectiva global dos auditores, *Qualidade*, n.b., p.n., disponível em: <https://recipp.ipp.pt/bitstream/10400.22/9682/1/ART_CIDEM_LMF_2016.pdf> (acesso em: abril 2022)

Fraga, S.V. (2011), 'A qualidade na construção civil: uma breve revisão bibliográfica do tema e a implementação da ISO 9001 em construtoras de Belo Horizonte', Monografia, Universidade Federal de Minas Gerais, Belo Horizonte, disponível em: <https://repositorio.ufmg.br/bitstream/1843/BUOS-9A5FLP/1/monografia_final.pdf> (acesso em: abril de 2022)

Gil, A.C. (2002), *Como Elaborar Projetos de Pesquisa*, 4ª ed, Atlas, São Paulo, disponível em: <https://home.ufam.edu.br/salomao/Tecnicas%20de%20Pesquisa%20em%20Economia/Textos%20de%20apoio/GIL,%20Antonio%20Carlos%20-%20Como%20elaborar%20projetos%20de%20pesquisa.pdf> (acesso em: abril 2022)

Guimarães, R.M. (2017), 'Auditoria interna no setor de suprimentos: um estudo de caso em empresa de construção civil', Monografia, Universidade Federal do Ceará, Fortaleza, disponível em: <https://repositorio.ufc.br/bitstream/riufc/35920/1/2017_tcc_rmguimaraes.pdf> (acesso em: maio 2022)

Januzzi, U.A. (2016), 'Sistemas de Gestão da Qualidade na Construção Civil: um estudo a partir da experiência do PBQP-H junto as empresas construtoras da cidade de Londrina', Dissertação de Mestrado, Universidade Estadual de Londrina, Londrina, disponível em: <http://repositorio.uem.br:8080/jspui/bitstream/1/3343/1/000179490.pdf> (acesso em: abril 2022)

Kanri, H. (2013), *Gerenciamento Pelas Diretrizes ("Hoshin Kanri")*, 5ª ed, n.b., n.p., disponível em: <https://pt.scribd.com/doc/29621330/Gerenciamento-Pelas-Diretrizes-Hoshin-Kanri>.

Meirelles, H.L. (2005), *Direito de Construir*, 9ª ed, Malheiros, São Paulo, disponível em: <https://docero.com.br/doc/v1588> (acesso em: abril 2022)

Nascimento, A.P., Pascuci, L.M., Nascimento, L.C. & Oliveira, M.P.V. (2017), 'A estratégia da qualidade ou a qualidade da estratégia? Uma avaliação da adoção da gestão estratégica na norma ABNT NBR ISO 9001:2015', *Revista Eletrônica Sistemas & Gestão*, vol. 12, no. 1, pp. 57-69, disponível em: <https://www.revistasg.uff.br/sg/article/view/1138> (acesso em: abril 2022)

Pelacani, V.L. (2010), Responsabilidade Na Construção Civil, CREA, Curitiba, disponível em: <https://www.crea-pr.org.br/

ws/wp-content/uploads/2016/12/caderno07.pdf> (acesso em: abril de 2022)

Pinheiro, M.R.A., Florencio, E.I. & Araujo L. (2018), 'Considerações a respeito das Principais Manifestações Patológicas em Pontes de Concreto Armado na Cidade de Recife', *3º Simpósio Paraense de Patologia das Construções*, Universidade Federal do Paraná, Curitiba, Paraná, 2-4 maio, disponível em: <https://web.archive.org/web/20200319190036id_/http://doi.editoracubo.com.br/10.4322/2526-7248.020> (acesso em: abril 2022)

Pujadas, F.Z.A. & Saldanha, M.S. (2012), *Norma de Inspeção Predial Nacional*, Instituto Brasileiro de Avaliações e Perícias na Engenharia, Bela Vista, São Paulo, disponível em: <https://www.ibape-sp.org.br/adm/upload/uploads/1545075662--NORMA-DE-INSPECAO-PREDIAL-NACIONAL-aprovada_em_assembl_ia_de_25-10-2012.pdf> (acesso em: abril 2022)

Sá, J.G., Santos, J., Sousa, T.C. & Sousa, R.R. (2015), *Guia do utilizador ISO 9001:2015*, APCER, n.p., disponível em: https://www.academia.edu/30053591/GUIA_DO_%20UTILIZADOR_ISO_9001_2015 (acesso em: 17 abril 2022)

Vieira, E.S. & Oliveira Neto, J.M. (2019), 'Qualidade na construção civil: PBQP-H análise do programa brasileiro de qualidade e produtividade do habitat', *Revista ETIS*, vol. 1, no. 1. pp. 54-64, disponível em: <http://periodicos.unievangelica.edu.br/index.php/etis/article/view/3180/2530> (acesso em: 07 abril 2022)

Yazigi, W. (2009), *A técnica de edificar*, 10ª ed, Pini, SindusCon, São Paulo, disponível em: <https://www.academia.edu/35905846/A_T%C3%A9cnica_de_Edificar> (acesso em: abril 2022)

**Received:** Nov 30 nov, 2022

**Approved:** Dec 8 dez, 2022

**DOI:** 10.20985/1980-5160.2022.v17n3.1834

**How to cite:** Brandão, R.M.L., Abreu, J.G.N., Siqueira, M.F. (2022). Relation between the findings of the quality audits and the pathological manifestations identified in the post-construction phase. Revista S&G 17, 3. https://revistasg.emnuvens.com.br/sg/article/view/1834