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PATHOLOGICAL MANIFESTATIONS IN BUILDINGS WITH REINFORCED CONCRETE WALLS: CASE STUDY IN THE CITY OF JOÃO PESSOA - PB

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Abstract: This work focuses on the evaluation of the pathological manifestations presented in the constructive system of cast-in- place concrete walls with the use of steel formwork. The case study was carried out in a condominium, located in the city of João Pessoa/PB, composed of 208 housing units distributed in 13 blocks, each of them containing 16 apartments. The objective of this article is to point out the pathological manifestations reported by the users of the buildings after the completion of the construction and the possible failures in the execution stage. The development of this study consists basically of a mapping of the pathologies through the occurrence reports registered by the users who requested technical assistance, where it could be verified that, of the of all occurrences recorded by the company, around 40% of them are related to, or are from systems that interface with concrete walls. In the next step, an on-site inspection to identify the nature and origin of the pathologies and diagnose the situation found seeking a solution to the problem. It can be concluded that the adoption of alternative processes used by the construction company can reduce or even avoid pathologies interfacing with concrete walls. Other measures such as the adoption of curing processes and better maintenance of steel formwork also appear as important elements in mitigating the undesirable effects caused by inadequate execution of concrete walls.
Keywords: Concrete walls; Metallic molds; Pathologies; Execution errors

INTRODUCTION

For some years now a new construction technology has been presenting itself as a viable alternative for a portion of the Brazilian housing market. The cast-in-place concrete walls are being implemented as a new building system, mainly in large-scale production buildings. This construction system has been standardized in Brazil since 2012 by NBR 16055:2012 - Concrete wall of cast-in-place concrete for the construction of buildings.

It is known that civil construction seeks to make use of structures that yield more agility. Cast-in-place concrete walls have been implanted as a new building system, especially in large-scale production. This building system has advantages, such as high productivity, reduction of the number of workers in the construction site and of craft activities. Consequently, a lower cost in the production process. It also reduces the final cost of the property.

With the growth of the Brazilian real estate market and several public measures to expand the supply of housing, such as the "Minha Casa, Minha Vida" program – an initiative of the Brazilian federal government, started in 2009, which encourages social interest housing, for example, this system has become more used in the enterprises, making this type of building more accessible to the population.

However, the concrete elements in this type of building system, as in any other any other, are subject to the appearance of pathological manifestations, which can compromise the performance and durability of structures. These pathological manifestations may come from executive failures, among other causes.

It is possible to perceive, therefore, the importance of the identification and direct action in the failures of execution of the constructive systems of this type of enterprise. The correction of the project and construction procedure has great repercussion on the units produced from then on. An identified and uncorrected problem replicates itself in all units built. Because these are large scale productions, the level of incidence of service provision by the company regarding repairs

and technical assistance to the customer can become very high, leading to increase in undesirable costs, as well as customer/user dissatisfaction.

In this scenario, the objective of this research is to evaluate the pathological manifestations reported by users of buildings after delivery of the and the possible failures in the execution stage.

METHODOLOGY

The starting point of this research was the identification, through inspections, of the pathological manifestations and their probable causes in housing units of the program "Minha Casa, Minha Vida" built by the method of cast-in-place concrete walls, arising from the execution stage, and to offer, in the end, possible solutions for the construction defects presented. This identification was conducted after the housing units were handed over to the residents, as a service requirement call was made to request technical assistance.

Another objective of this work was to elaborate a list of all the pathological manifestations registered in the enterprise in question so that to be able to execute the necessary improvements for a better use of the constructive system by the company and avoid the same setbacks mishaps in future works.

CONSTRUCTION PROCEDURE

The cast-in-place wall system was standardized in Brazil from 2012 by NBR 16055:2012 - Concrete wall molded in place for the construction of buildings. This is a construction system in which the final product presents structure and sealing formed by a single element. Its installation elements (electrical, plumbing, etc.), as well as window frames, are usually embedded at the time of molding.

The main advantages presented by the system are the increase in productivity and the decrease in the use of labor. Consequently, the reduction of costs and economic gains. A disadvantage that could be pointed out is the high cost of acquiring the molds. For this reason, an economic feasibility study must be done.

The enterprise cited in this case study consists of 208 housing units distributed in 13 blocks. Each block has 4 floors containing 4 apartments each, as shown below in Figure 1.

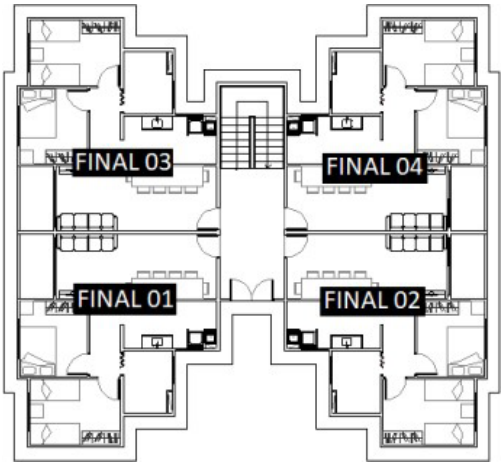


Figure 1. Ground Floor Plan (Construction Company Archive, 2020)

The execution starts from the positioning of the reinforcement (waiting for the screens), as illustrated in Figure 2.At this moment it is extremely important to check the axis, because it is from this axis that the formwork positioning lines will be marked. Next, the welded wire mesh is positioned in the vertical position and the folded steel placement of "L" folded steel screens in the corners of all walls. After this step, the screens will be cut in the places where the window and door openings will be doors, as seen in Figure 3 below.

After the reinforcement and stiffeners have been positioned, plastic spacers are inserted to ensure the centrality of the are inserted to ensure the centrality of the reinforcement and embedded systems.

An important characteristic of the "Concrete Wall" system is that it allows after the stripping, the walls contain, embedded in their interior, all the elements foreseen in the project, such as: electrical conduits, electrical boxes QDL and VDI boards, hydraulic and sanitary piping, among others.

The fixing is carried out by fasteners tied to the reinforcement and spacers to guarantee the centrality of the elements and spacing of the boxes to the opposite face of the walls, as observed in Figure 4. In elements that have holes through which concrete can enter (or "leak"), such as electrical boxes (or "leak"), such as electrical boxes, for example, fillings must be made with paper or sawdust with paper or sawdust, thus preventing the concrete from obstructing the holes of the electrical ducts.

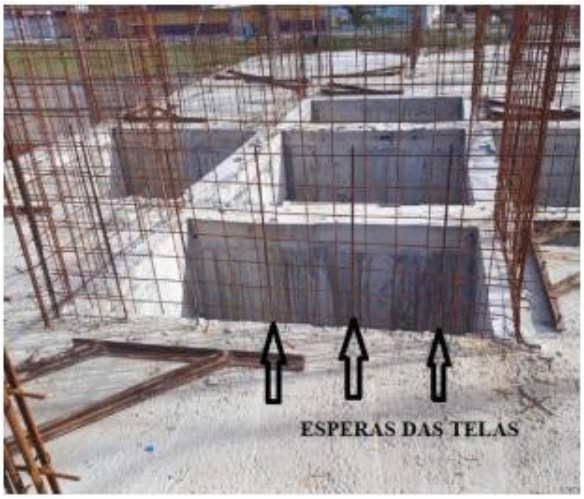


Figure 2. Demarcation of the wall and positioning of the mesh (Construction Company Archive, 2020).

Figure 3. Cutting out the mesh for span of window (Construction Company Archive, 2020).

Figure 4. Electrical boxes for walls (Construction Company Archive, 2020).

Once all these stages are completed, the panels of the metal formwork can be positioned on the wall. Figure 5 demonstrates this step. It is recommended that the formwork be clean and that application of the demolding agent to facilitate the demolding. We used metal molds with the with the necessary resistance to the actions to which they are subjected during the construction process.

Figure 5. Metallic forms in assembly process (Construction Company Archive, 2020).

The concreting is carried out on all construction days, that is, from Monday to Friday. They are divided into 2 flats/day, as shown in Figure 06. Considering this schedule, the structure of a tower is built in 8 working days. When the concrete structures of a block are finished, the formwork is allocated to the next one. They are reused throughout the construction and, when necessary, undergo occasional repairs.

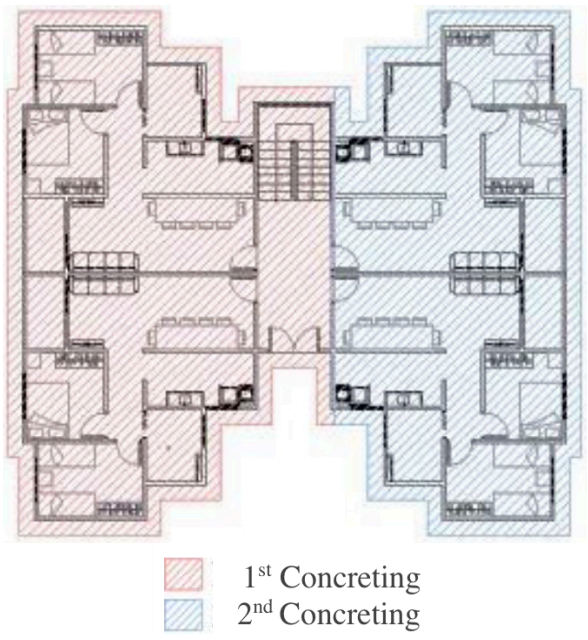


Figure 6. Metallic forms in assembly process (Construction Company Archive, 2020).

The main component - the concrete - used was with characteristic strength of 30 MPa and slump of 20 ± 2. It is essential that the concrete has good workability for complete the molds, to avoid segregation and ensure a good surface finish.

PATHOLOGICAL MANIFESTATIONS IDENTIFIED

Concrete can suffer changes over time and due to some of these changes can arise anomalies that damage the structure. Often, the appearance of the manifestations of pathologies of concrete are from failures in the execution stage of the structure. Unqualified labor, lack of quality qualified labor, lack of quality control of materials, processes and attention to construction details can result in pathological manifestations that can be observed immediately or throughout the useful life of the dwelling. Examples can be such as shoring, formwork, bracing, positioning of the reinforcement and embedded systems.

With the help of the company's technical assistance area, which complaints and requests for repairs from end users during the warranty period warranty period, which

is 5 years from the date of receipt by the condominium, the report of occurrences of the enterprise. Through this survey conducted by the by the construction company, it was verified that of the 208 housing units delivered in 2020, 40% of the properties had construction defects within the warranty Percentual de Ocorrênciasperiod, the most cited being the following occurrences and needs for repairs were the most cited the following occurrences and repair needs are shown in Graph 1.

In relation to Graph 1, it should be noted that the ceramic cracks and fissures in the room ceramics pass through the conduit, and there are worn and damaged ceramic tiles. This last one will not be detailed as it is irrelevant to this study.

Frames/leaks are divided into two categories: wooden frames that are out of square and and infiltrations in the facades from aluminum frames (windows). Both can be a function of poor execution of the openings and will be counted as having to do with the concrete walls. Some infiltration occurs due to the appearance of cracks caused by the non-uniformity of uniformity of the concrete or by the non-regularized geometry of the span, linked to faulty sealing in the placement of the window frames.

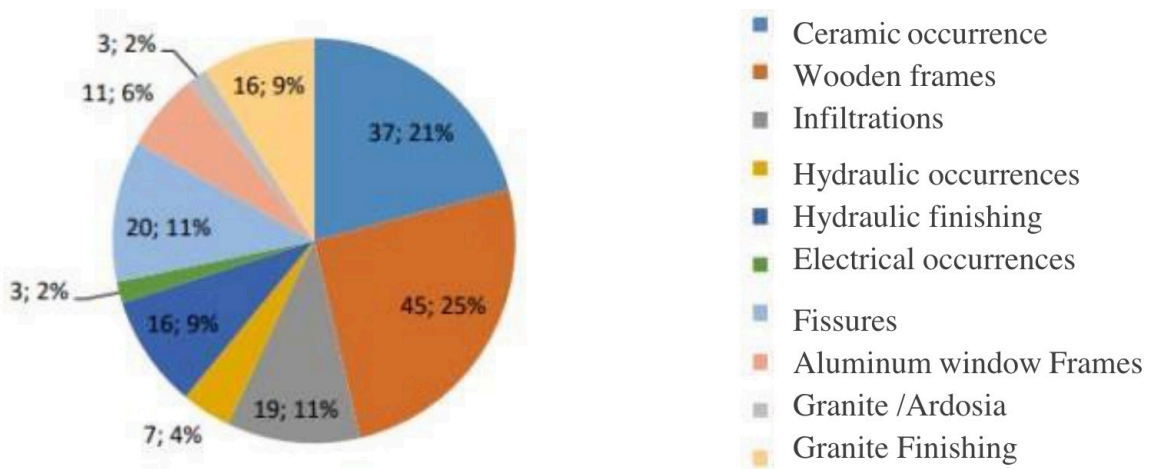
Problems in hydraulic installations include leaks, clogs, malfunctions, defects in the dishes and pipes. They will not be counted as having any relation with the concrete walls. Electrical installations involve electrical boxes out of alignment and out of square.

There is the occurrence of cracks and fissures in the structure of the walls of the room in the of the room walls in the region of the formwork joints, on the wall of the room where the air drainage pipe and in the window opening, forming an angle of 45°.

The aluminum window has a damaged lock or glass. They will not be counted as having to do with the concrete walls.

The Granite/Ardosia tiles located in the kitchen as a partition to the service area, presented a small gap or malfunction. They will not be counted as having relation to the concrete walls.

Each item mentioned was verified, inspected in each housing unit, and corrected so that they do not compromise the stability and safety conditions of the stability and safety of the properties.



Graph 1. Percentage of occurrences (Construction Company Archive, 2020).

IDENTIFICATION AND CORRECTION OF PATHOLOGICAL MANIFESTATIONS

Among the 37.21% of complaints of cracks in ceramics, 16.43% of them were from the failure of the covering of the conduits, that is, when there is interference, such as iron fittings, conduits, or any element inside the concrete mass inside the concrete mass, if the cover is insufficient, after the concrete, when supported on these interferences, it bends, causing cracks. Poor positioning of the spacers or excessive vibration on site, move the conduits and, consequently, reduce their cover.

Another factor observed was shrinkage by drying, because, by properly curing of the concrete, which should be thoroughly watered in the first days of life, the sun exposure or excessive heat of the environment can be prevented from causing the drying out of the newly poured concrete. These situations cited caused cracks in the slab, reaching the subfloor and even the detachment of them in the ceramic tiles, as observed in Figure 7.

Figure 7. Crack in the floor due to failure in the covering of the conduit (Construction Company Archive, 2020).

The correction of this pathological manifestation, as shown in Figure 8, was made through the removal of the cracked ceramic tiles, the laying mortar and removal of the regularizing layer of the subfloor. Next, the micro-crack was reopening and cleaning of the micro-cracks in the concrete slab, application of polyurethane sealant structured with polyester mesh on the entire extent of the crack. Finally, the subfloor was resurfaced; a layer of polyester mesh was applied with ACII mortar and new ceramic tiles were reseated.

Observing the photos in Figure 8, the first image shows the application of polyurethane sealant, known as "PU". This material has the function of sealing joints and openings between substrates, preventing water, air or other substances from entering or leaving the structure. In addition to the sealants' ability to move with the substrate where it has been applied. The central image shows the application of the polyester fabric or polyester veil with the purpose of distributing the tensions in the tensions in regions of greater movement. And the photo on the right shows the resettlement of the new ceramics and, therefore, the finished service.

The locking and alignment after inserting the door and window frames and window frames, as well as regularizing their geometry, are fundamental to ensure that the spans are not out of square, as illustrated in Figure 9. For, this flaw directly interferes with the installation and functionality of the frames. Of the 45.25% of requests for assistance, 10% came from doors leaning against the ceiling or the floor, making it difficult to close them, making it difficult to close them. As a result, for regularization, there was an excessive consumption of material due to the great thickness required of the mortar layer for settlement.

Figure 8. Correction of a crack in the floor due to a failure of the failure of the conduit cover (Construction Company Archive, 2020).

Figure 9. Doorway out of square (Construction Company Archive, 2020).

In some cases, infiltration occurs through the appearance of cracks forming angle of 45° with the horizontal, caused, normally, by lack or bad positioning of the reinforcement around these spans linked to a faulty sealing in the placement of the faulty sealing in the placement of the frame. This example can be seen in Figure 10.

For correction (Figure 11), the micro-cracks were reopened in the layers of paint and mass until it reached the concrete; then the reopening of the micro-crack in the concrete, cleaning of the micro-crack and application of acrylic resin-based crack sealer. Finally, the finishing is done with plastering and painting.

A common scenario after stripping was the misaligned and out-of-round electrical boxes misaligned and out of square, because of the clamp attached to the box, which the steel mesh, could not resist the efforts of the concrete efficiently, as shown in Figure 12.

Among the occurrences in the wall structure, we can mention the region of the formwork joints of the forms, where the failure in the concreting in this region, identified independently segregation due to the accumulation of concrete, which caused the exit of due to poor formwork sealing, in addition to a wall with a rough and porous surface. Figure 13 is an example of the cases observed.

Figure 10. Infiltration at window frames (Construction Company Archive, 2020).

Figure 11. Correcting infiltration in window frames (Construction Company Archive, 2020).

Figure 12. Misaligned electrical boxes (Construction Company Archive, 2020).

Figure 13. Wall with porous and rough surface (Construction Company Archive, 2020).

Another reported crack was in the wall of the bedroom where the air-conditioning drainage pipe runs. And, in the room from the opening of an electrical box, which are caused by the lack or poor positioning of the reinforcement. For correction, the micro-cracks were reopened in the layers of paint and mass until it reached the concrete; then the reopening of the micro-crack in the concrete, cleaning of the crack and application of acrylic resin-based crack sealer. Finally, plastering and painting in the crack location. As shown in Figure 14. A image on the left shows the correction made in the room starting from the opening of an electrical box. The image on the right side shows the bedroom wall, where the air-conditioner's drainage pipe.

Another request for technical assistance that was frequently reported by the residents after the delivery was that the walls were out of square. According to the manufacturer, the formwork, after assembled, would not move. However, it was found that several walls were out of plumb and square, due to their displacement. This example can be seen in Figure 15, where the floor is squared due to the paging done in the project. To treat the walls with this constructive flaw, an analysis was performed to define which procedure would be best: filling or scarifying these walls.

FINAL REMARKS

It was evidenced in this work, that the constructive system of concrete walls, despite being considered rationalized and presenting as its main advantage its productivity, presented, in this case study, several constructive flaws, generating rework and, consequently, reducing its productivity. It is worth pointing out that the flaws found were not from the constructive system, but from its execution.

In practically all the problems encountered, training of the production team was necessary to the production team to avoid reoccurrence of the cases, making clear the need for a qualified workforce to perform the construction stages of this system. of this system. The preventive measures and solutions to the problems adopted during the execution of this enterprise showed to be capable of solving the errors found, and their exposure may serve to avoid their occurrence in other buildings that use this system.

Finally, the importance of quality in the execution of this construction system, to avoid rework and additional costs that undermine the rationalization that the system seeks to provide.

DECLARATIONS

AUTHOR CONTRIBUTIONS

Conceptualization, K.P.V.C. and F.C.M.; methodology, K.P.V.C. and F.C.M.; writing—original draft preparation, K.P.V.C.; writing—review, editing and translation, F.C.M.; supervision, F.C.M and L.M.; funding acquisition, L.M. All authors have read and agreed to the published version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

Figure 14. Wall crack repair (Construction Company Archive, 2020).

Figure 15. Out of square wall (Construction Company Archive, 2020).

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