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STRATEGIC DIAGNOSIS FOR IMPROVEMENTS IN THE EXECUTION OF STRUCTURAL MASONRY

José Afonso Rocha
Universidade Estadual Paulista` "Júlio de Mesquita Filho" (UNESP), (FEC), Department of Energy Engineering
http://lattes.cnpq.br/6262181329173115

Carlos Toshiyuki Hiranobe
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculty of Engineering and Sciences (FEC), Department of Energy Engineering
https://lattes.cnpq.br/6394135976740037
https://orcid.org/0000-0002-5182-2018

Márcia Ferreira Hiranobe
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculty of Engineering and Sciences (FEC), Department of Tourism and Territorial Enterprise
https://orcid.org/0009-0006-0131-0926

Samara da Silva Araújo
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculty of Engineering and Sciences (FEC), Department of Energy Engineering
http://lattes.cnpq.br/5133372950554813
https://orcid.org/0000-0003-4755-3385

Matheus da Silva Filgueira
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculty of Engineering and Sciences (FEC), Department of Energy Engineering
http://lattes.cnpq.br/3820896616062986
https://orcid.org/0000-0002-8525-1225

Gabriel Deltrejo Ribeiro
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculty of Engineering and Sciences (FEC), Department of Energy Engineering
http://lattes.cnpq.br/3536726680653435
https://orcid.org/0000-0003-2668-583X

Henrique Pina Cardim
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculty of Engineering and Sciences (FEC), Department of Energy Engineering
http://lattes.cnpq.br/3107203556922359
https://orcid.org/0000-0002-0752-0442

Jeferson Shiguemi Mukuno
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculty of Engineering and Sciences (FEC), Department of Energy Engineering
http://lattes.cnpq.br/2915437648487967
https://orcid.org/0009-0001-0943-6463

José Francisco Resende da Silva
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculty of Engineering and Sciences (FEC), Department of Energy Engineering
http://lattes.cnpq.br/3023885342426808
https://orcid.org/0000-0002-4671-0740

Rodrigo Piernas Andolfato
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculdade de Engenharia de Ilha Solteira (FEIS), Department of Civil Engineering
http://lattes.cnpq.br/6386709348716831

Jefferson Sidney Camacho
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculdade de Engenharia de Ilha Solteira (FEIS)
http://lattes.cnpq.br/5552821579207675

Renivaldo José dos Santos
Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Faculty of Engineering and Sciences (FEC), Department of Energy Engineering
http://lattes.cnpq.br/0254580245173848
https://orcid.org/0000-0002-0079-6876

Abstract: This study investigates the criteria used in the various stages of construction of works with structural masonry. The objective is to compare them with ABNT standards and technologies available on the market, in order to guarantee the quality of constructions. The research focuses on buildings that use concrete and ceramic blocks with a structural function, analyzing the labor, the quality of the components (blocks, mortar, grout and reinforcement) and the equipment used. The procedures from adapting the construction site to the execution and production of masonry are compared with ABNT standards and available technologies. Surveys at construction sites in the cities of São Carlos/SP, Araçatuba/SP, São José do Rio Preto/SP, Jaboticabal/SP, Londrina/PR and Blumenau/SC provide data on the execution of works. The research also investigates the manufacture of blocks (concrete and ceramic), seeking information about their resistance, aesthetic characteristics, durability and quality control parameters. Surveys at manufacturing companies in São José do Rio Preto/SP, Itu/SP, Limeira/SP and Americana/SP complement the research. The study aims to guarantee quality in the execution of works with structural masonry, from the production of blocks to on-site procedures. Comparison with ABNT standards and available technologies is essential to guarantee the quality of constructions.
Keywords: Structural masonry, housing enterprises, tools, executive procedures, quality.

INTRODUCTION

Since prehistoric times, man has sheltered in masonry buildings, initially stacking stones and, later, developing techniques to manufacture bricks. Adobe, made of clayey soil, sand and water, was an initial milestone, followed by the technique of baking bricks in ovens, which provided greater resistance (DORMOHAMADI, M.; RAHIMNIA, R., 2020). Romans and Egyptians developed construction systems with specific characteristics of the materials of the time, using pyramidal, portico and arch systems (OIKONOMOU, A., 2022). Masonry went through several stages, until it was once again recognized as a rational, safe and economical system (PETTIT, C. E. J., 2023). In the 20th century, the cement industry and the dominance of steel boosted reinforced concrete structures, which dominated the market for decades (DA CUNHA, G. R.; MOASSA, A., 2022). From the 1950s onwards, research and improvements in calculation and mathematical models revitalized structural masonry (LOURENÇO, P. B.; FUNARI, M. F.; SILVA, L. C., 2022). Structural masonry now offers savings, safety, quality and speed in execution. It is used in different types of constructions, from houses and townhouses to medium and large buildings. In Brazil, structural masonry was consolidated in the 1970s, with the creation of standards and research that guaranteed the quality and safety of the system. Currently, it is one of the most used construction systems in the country (CHAGAS, L. S. V. B.; OLIVEIRA, J. V. C.; CARNEIRO, M. P., 2020).

STRUCTURAL MASONRY

Structural masonry is highlighted as a crucial technique in civil construction, aiming to improve the quality and productivity of processes, seeking to reduce costs. In recent years, this technique has gained prominence in Brazil, initially due to its efficiency in reducing costs and speed of construction, being a response to the housing deficit. Over time, it evolved into medium and high-end enterprises, both horizontal and vertical, with the enterprise of specific standards. Structural masonry consists of walls that function as resistant elements, made up of blocks joined by mortar joints. This system eliminates the need for beams and pillars, using the walls themselves as a structure.

To choose the appropriate blocks for the project is fundamental and must be modulated to ensure a coherent construction. The use of vertically hollow blocks facilitates the construction process, reducing the weight of the pieces and allowing for savings on mortar, in addition to enabling the passage of installations. The resistant capacity of masonry to compression generally eliminates the need for reinforcement, however, in cases of lateral forces, such as wind, they may be necessary. In these cases, the walls can be reinforced with steel bars and grout (MEDEIROS, W. A.; PARSEKIAN, G. A.; JR MORENO, A. L., 2021).

In the context of structural masonry in Brazil, standards and definitions are established by the Brazilian Association of Technical Standards (ABNT). These standards cover a variety of components, such as blocks, mortar joints, grout reinforcement, reinforced or unreinforced masonry elements, structural and non-structural walls, beams, girders, among others. Furthermore, concepts such as gross, net and effective area are defined, along with direct and indirect mooring standards, which are fundamental for the adequate dimensioning and execution of structures (MEDEIROS, W. A.; PARSEKIAN, G. A., 2021).

STRUCTURAL MASONRY SYSTEM

The structural masonry construction system is made up of a variety of materials, components and essential elements. These basic components must meet minimum performance requirements and comply with established standards, guaranteeing the quality of the system. Blocks play a fundamental role in this system. Both ceramic blocks and concrete blocks are essential for determining important characteristics of walls, such as strength, stability and thermal insulation. Ceramic blocks go through a manufacturing process that includes laboratory analysis, crushing, mixing and drying, while concrete blocks are produced with different traits and vibro-pressing processes. Both types of blocks must meet strict quality criteria, such as mechanical resistance, dimensional accuracy and water absorption within specific limits (MUNERON, L. M.; et al., 2021).

Mortars have the function of joining the blocks in the masonry, distributing loads, compensating for imperfections and sealing the wall against aggressive agents. Choosing the appropriate type of mortar is crucial to guarantee the strength and durability of the wall, avoiding problems such as cracks and low adhesion (SHADLOU, M.; AHMADI, E.; KASHANI, M. M., 2020).

Grout, a mixture of concrete or mortar with high plasticity, is used to fill voids in the blocks and increase the localized strength of the wall. Its application must follow specific standards to guarantee the quality of the wall (MOHAMMED, A.; MAHMOOD, W.; GHAFOR, K., 2020).

Reinforcement, steel elements used to increase the resistance of structural masonry, must meet strict technical specifications to guarantee their effectiveness, including resistance and corrosion protection standards. The correct placement of reinforcement is essential to guarantee its effectiveness, with

different devices being used to keep it in the correct position during filling with grout (GKOURNELOS, P. D.; TRIANTAFILLOU, T. C.; BOURNAS, D. A., 2022).

Masonry walls are essential components of structural masonry construction, responsible for supporting vertical loads and transmitting efforts to the ground or supporting structure. They must be designed taking into consideration, the predominant efforts, such as simple compression, traction and shear, in addition to considering aspects such as thermal, acoustic comfort and tightness. The correct execution of the walls, using the appropriate materials and techniques, is essential to guarantee the safety, durability and efficiency of the structural masonry construction system.

RECENT ADVANCES IN STRUCTURAL MASONRY

Today, structural masonry continues to play a crucial role in the construction of housing, commercial buildings and urban infrastructure. However, we have more advanced materials and techniques than ever before. Concrete blocks, ceramic bricks and other modern building materials are designed to offer not only structural strength, but also energy efficiency, sustainability and ease of construction.

Hongwang and Gaire (2020), designed a new type of mortise compressed earth block, developed at Shanghai Jiao Tong University, for use in structural masonry. The fitting mechanism of this block depends completely on the grout in the vertical holes, thus eliminating spaces between the fitting keys and the blocks, which increases the stability of the wall and reduces the manufacturing costs of the blocks. The study includes experiments to evaluate the mechanical behavior of the individual block and masonry constructed with dry blocks. Soil samples from northern China's Gansu Province were collected and tested to determine compressive and shear tensile strength. Furthermore, compressive strength tests were carried out on prisms constructed with three stacked blocks without grout, and the shear strength of the masonry was investigated through triplet tests. The results show that both compressive strength and shear strength meet related standards. The work suggests that this structural system could offer a valuable solution for low-cost, environmentally friendly housing in developing countries.

Studies on structural masonry are not restricted to research into new structural block composites. A bibliographical review conducted by researchers Szabó, Funari and Lourenço (2023) about unreinforced masonry walls, that is, those without internal reinforcement, such as steel bars or metal mesh, revealed the scarcity of studies on masonry textures. These textures result from different arrangements, rearrangements and geometries of bricks and blocks. This scenario arises from the current difficulty in finding parameters that establish a correlation between masonry standards and structural performance. This article presents a broad review of existing geometric measurements for irregular masonry patterns, highlighting gaps and possible future trends. Also noteworthy is the special attention dedicated to Non-Destructive Testing (TND) for surveying masonry textures, as well as the algorithms used to generate numerical models based on artificially shaped blocks. Finally, a numerical investigation highlights how masonry textures, when generated considering quality indices, produce more consistent results.

With advances in information technology, preliminary studies on structural masonry have been conducted in modeling and simulation laboratories before producing a pilot-scale prototype. Lourenço and Silva

(2020) present a set of advanced models for the mechanical study of masonry, which encompass microscopic modeling approaches (the masonry constituents, unit and joint, are represented separately), macroscopic modeling (the masonry constituents are distributed in a homogeneous composite) and multi-scale techniques (increasing from micro to macro scale is adopted). A comprehensive overview of its computational characteristics is provided. The practical application of these strategies is presented, covering problems from the level of masonry components (mesoscale) to the structural element itself, and, finally, to the level of monumental buildings (super large). The assessment of structural safety and/or the evaluation of reinforcement schemes is carried out in static situations, slow dynamics such as earthquakes, and fast dynamics such as impacts and explosions.

In view of the above, carrying out this research work is extremely important to understand and analyze the processes involved in the production and execution of structural masonry. The objectives of the research include observing in detail the manufacturing processes of the blocks, from the selection of materials to palletizing for delivery, as well as diagnosing the procedures adopted at construction sites for the execution of structural masonry in accordance with ABNT standards.

Through surveys carried out in concrete block and ceramic factories, as well as on construction sites in different cities, it is possible to obtain a comprehensive view of the methods used in practice. With the increasing use of structural masonry, it is essential to understand how construction companies have adapted to this system, taking advantage of its advantages, such as the reduction of shapes, frames and coverings, in addition to the prefabrication of structural components.

Structural masonry projects not only promote efficiency in construction, but also contribute to boosting the economy in several regions of the country. In this favorable scenario, it is essential that everyone involved in the production chain pays attention to the quality and safety of constructions.

Therefore, this research work seeks not only to observe the execution and control procedures of works on construction sites, but also to compare them with established standards, aiming to analyze the quality levels applied in structural masonry buildings. This analysis is crucial to ensure that quality and safety objectives are achieved, promoting a more reliable and sustainable construction environment.

METHODOLOGY

EXECUTION AND CONTROL OF STRUCTURAL MASONRY WORKS

The execution and control of structural masonry works establishes minimum requirements to ensure compliance with standards during the execution of works. This includes the need for prior characterization of materials, such as blocks, mortar and grout. To ensure the quality of execution, it is essential to follow a quality control plan, as described in ABNT NBR 16868-1:2020. This plan must detail those responsible for control, the circulation of information, the treatment of non-conformities and the recording of information. Controlling the production of mortar and grout during construction is also essential, with tests in defined batches. Furthermore, the specification and control of blocks must follow specific standards, such as ABNT NBR 6136 for concrete blocks and ABNT NBR 15270-2 and 15270-3 for ceramic blocks.

Other materials that make up the masonry, such as metal reinforcement, also need to be specified and controlled according to the corresponding standards. It is crucial to control the resistance of materials and masonry to axial compression, with prior characterization of the materials or use of test results from manufacturers, as long as they are within a period of 180 days (VIENNI, C.; ORLANDO, M; SALVATORI, L., 2024). When controlling masonry production, it is necessary to ensure the correct location, squares, leveling and cleaning of the floor, in addition to following the project specifications. Acceptance of the masonry is based on the results of compression tests on the blocks or prisms, with corrective action in case of nonconformities, which may involve design review, structural reinforcement or partial or total demolition.

TOOLS AND EQUIPMENTS

The use of tools and equipment when carrying out structural masonry works highlights their importance in ensuring the quality and precision of tasks, which translates into savings and increased productivity. Traditional tools include a trowel, face plumb, nylon line, steel tape measure, brush, sledgehammer, chisel, among others. Specific tools for structural masonry include items such as adjustable scaffolding, tube, half-round spoon, template, German level, mortar palette, among others (FLYNN, B., 2011).

The adjustable scaffolding is mounted on a mobile base and provides a continuous walkway along the masonry in progress. The tube allows for more productive and economical block laying. The template, fixed to the lower slab, guarantees the plumb and flatness of the walls. The German level makes leveling easier in different situations. The mortar palette, level ruler and plumb ruler are essential for leveling and plumb walls. The dough cart and grout bucket provide practicality and efficiency in carrying out the service. Door and window templates guarantee precise dimensions and regularity in installations. The pallet cart contributes to the quick and safe transport of blocks.

These tools and equipment play a fundamental role in ensuring the quality and efficiency of structural masonry works.

RESULTS AND DISCUSSION

ANALYSIS OF BLOCK MANUFACTURING COMPANIES AND PROCEDURES AT CONSTRUCTION SITES

In this section, block manufacturing companies are presented, whose manufacturing methods and block attributes are examined, together with the procedures adopted at construction sites, with the aim of comparing these methods with established regulations.

In the municipality of São José do Rio Preto/SP, Company 1 manufactures structural concrete blocks, with strengths ranging from 4.0 MPa to 12 MPa, using specific procedures to guarantee the characteristics defined in projects. It carries out laboratory tests to control the resistance of the blocks and produces a monthly average of 100,000 units.

Company 2, also in São José do Rio Preto/SP, manufactures concrete structural blocks with strengths from 4.0 MPa to 6 MPa, maintaining similar manufacturing criteria to Company 1, but without promoting affiliation with the Brazilian Portland Cement Association (ABCP) nor implement quality control systems. It produces a monthly average of 85,000 units.

In the city of Limeira/SP, a company manufactures concrete blocks with strengths ranging from 3 MPa to 16 MPa. It has a quality system, is affiliated with ABCP and

carries out tests in its own laboratory. It produces a monthly average of 1,500,000 units, with efficient storage and transportation procedures.

In Americana/SP, a company manufactures concrete structural blocks with strengths between 4.0 MPa and 25 MPa. Affiliated to ABCP, it maintains a quality program with control of the manufacturing process and tests in its own laboratory. Produces 1,600,000 units per month, with control over the manufacturing process and efficient operational logistics.

In Itu/SP, a leading company in the market produces ceramic structural blocks with varying resistances. It uses a high level of control in the manufacturing process and promotes visitation activities at its facilities. It carries out tests in its own laboratory and attaches great importance to the identification of manufactured batches for traceability. It produces an average of 2,500,000 units per month.

At construction sites, the purpose of the investigation was to observe and contrast the methods used to carry out structural masonry, considering the guidelines established by ABNT standards.

ENTERPRISES IN THE CITY OF SÃO CARLOS/SP

The first enterprise consists of two towers with ground floor and twelve standard floors, each floor housing six apartments measuring 65.00 m². For the foundations, root piles were used, while the masonry was carried out with concrete structural blocks in different dimensions, following ABNT standards. Prisms, grout and mortar were tested for compressive strength. When executing the masonry, reinforcement was detailed to promote connections between walls and guarantee their stability. The grouting of the blocks was carried out after cleaning the holes and fixing the reinforcement, with cuts in the blocks to facilitate the process. The roof was made with reinforced concrete slabs, and the stairs were made of pre-cast concrete. Internally, plaster will be used as a coating, while externally, a monolayer coating will be applied. The construction administration demonstrated concern with the conformity of services, investing in training and technology, and following a modulation project to standardize the blocks.

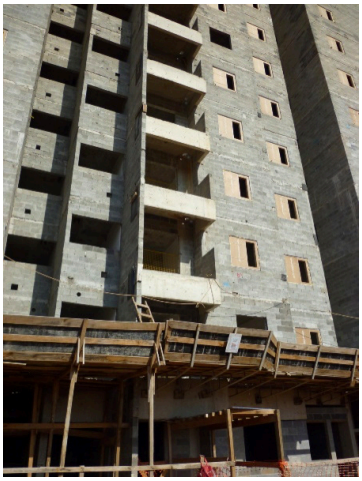

Figure 1: Enterprise 1 in the municipality of São Carlos/SP.

Source: own elaboration.

In the second enterprise, consisting of a tower with basement, ground floor and ten standard floors, each with three apartments of 75.00 m². The foundations were made with continuous helix piles, while the masonry used concrete structural blocks, also following ABNT standards. Prisms, grout and mortar were tested for compressive strength.

When executing the masonry, traditional tools such as a trowel, rubber hammer, level, plumb line and square were used, following markings according to the central axis and dimensions of the modulation project. The internal covering will be done with plaster, and the external with mortar on plaster. The administration of the work was focused on

improvements and procedures compatible with the construction system, counting on an experienced team that adopts the structural masonry construction system in most projects.

Figure 2: Enterprise 2 in the municipality of São Carlos/SP.

Source: own elaboration.

ENTERPRISE IN THE CITY OF LONDRINA – PR

The enterprise in the city of Londrina, PR, consists of four towers, ground floor plus seven standard floors, with six apartments per floor, each with an area of 58.00 m². The foundations were made with excavated piles, while the structural masonry used concrete blocks in different dimensions, following ABNT standards. Prisms, grout and mortar were tested for compressive strength. The execution of the masonry followed markings according to the central axis and dimensions defined in the modulation project, maintaining squares, plumb lines and levels of the laid rows. The floor slabs were made of reinforced concrete, and the stairs were made of pre-molded pieces. On the roof, a PVC plate and 3 cm EPS plate were installed and finished with plastic canvas. Traditional tools such as a trowel, rubber hammer, metal ruler, level, plumb line and square were used to carry out the masonry. The company demonstrated concern with the quality and solidity of the projects, maintaining a qualified technical and administrative structure at the construction site. They periodically carry out training for workers and maintain a policy of hiring female labor. However, the execution of the masonry with compensators proved to be less effective, resulting in some points with negative aspects in the settlements.

Figure 3: Enterprise 1 in the municipality of Londrina/PR.

Source: own elaboration.

ENTERPRISE IN THE CITY OF ARAÇATUBA – SP

In the first enterprise in Araçatuba, SP, we have a tower with a ground floor and 7 standard floors, with 4 apartments per floor, each measuring 86 m². The foundations were made with rafts, and the masonry used concrete structural blocks in various dimensions, following ABNT standards. Tests on components, such as blocks, prisms, grout and mortar, were carried out in accordance with the relevant standards. The grouting was done after cleaning the holes and installing the reinforcement, with emphasis on the perimeter masonry on the ground floor, which had 100% of the blocks grouted and reinforced vertically. The company demonstrated mastery of the construction system, maintaining partnerships with suppliers and promoting training for workers.

Figure 4: Enterprise 1 in the municipality of Araçatuba/SP.

Source: own elaboration.

In the second enterprise, with 16 towers, ground floor plus 2 standard floors, and 4 apartments per floor measuring 75 m² each, the foundations were also made of raft. The masonry used structural blocks according to specific dimensions, with trials and tests following ABNT standards. The roof had a plat band over a cantilevered slab, minimizing pathologies. The execution of the masonry followed modulation standards that favor the rationalization of execution. All technical and administrative procedures were similar to the first project, with an emphasis on quality and rationalization of activities. The tools used and the training procedures for workers were maintained, ensuring efficiency in the execution of the works.

Figure 5: Enterprise 2 in the municipality of Araçatuba/SP.

Source: own elaboration.

ENTERPRISE IN THE CITY OF SÃO JOSÉ DO RIO PRETO – SP

In this enterprise, seven towers were built with a ground floor plus three standard floors, each containing eight apartments per floor, with an area of 49.00 m² each. The foundations were made with open-air pipes, while the masonry used concrete structural blocks in different dimensions, as well as channels and compensators. The workers used tools such as a trowel, tube and rubber hammer in the construction. Grouting was carried out in the indicated locations after cleaning the blocks, following the project. The structural project was prepared by a local professional, contributing to a more precise execution. The concrete blocks were tested in accordance with ABNT standards, seeking to obtain compressive strength values and other parameters. The floor slab was initially pre-cast 3 cm thick and then complemented with a solid 7 cm slab.

The staircase was made with pre-cast concrete pieces. The internal covering was done with plaster, followed by painting. The construction company has experience in the market and works with the same suppliers and professionals in several projects, maintaining quality standards. The modulation project contributed to rationalizing the execution of the masonry, eliminating the need for complementary pieces.

Figure 6: Enterprise 1 in the municipality of São José do Rio Preto/SP.

Source: own elaboration.

ENTERPRISE IN THE CITY OF JABOTICABAL – SP

In this enterprise, a tower was built with a ground floor plus three standard floors, with eight apartments per floor and an area of 65.00 m² each. The foundations were made with excavated piles, while the masonry used ceramic structural blocks in different dimensions, as well as channels, compensators and special "J" type blocks. The testing and testing procedures followed ABNT standards, with an emphasis on the compressive strength of the materials. The grouting was preceded by cleaning the holes in the blocks, arranging the reinforcement and respecting the geometric specifications of the masonry. High-density sheets were placed between the covering slab and the masonry to contribute to structural movements. The standard floor slabs were supported on channel block supports and special "J" blocks. Despite not using appropriate tools, the work continues with quality control, but the visual aesthetics are not favorable due to some non-conformities in the execution. The construction company operates in several cities in the central region of the state and uses concrete structural blocks in its projects.

Figure 7: Enterprise 1 in the municipality of Jaboticabal/SP.

Source: own elaboration.

ENTERPRISE IN THE CITY OF BLUMENAU – SC

In project 1, two towers were built with two basements and 14 standard floors, each with eight apartments per floor and an area of 66.00 m² each. The foundations were made with pre-cast concrete piles, while the masonry used concrete structural blocks in different dimensions, channels, compensators, inserts and special blocks. The workers used specific tools to carry out the masonry, following markings defined in the project. The supplier company maintains a Quality Program for its products and offers courses for workers. The materials are tested in accordance with ABNT standards, aiming to guarantee the quality of the work. The structure of the work has equipment that contributes to the rationalization of services. Masonry services are controlled to obtain quality standards, with the active participation of contractors.

Figure 8: Enterprise 1 in the municipality of Blumenau/SC.

Source: own elaboration.

In Enterprise 2 in Blumenau, a tower was built with 15 standard floors, containing nine apartments per floor, each with an area of 72.00 m². The foundations were made with metal piles (profiles), and the masonry used concrete structural blocks, channels, compensating blocks, inserts, "J" blocks and hydraulic blocks. Tests on the materials followed ABNT standards to ensure

adequate resistance. During the work, the finishing of each apartment is being carried out as negotiated with the owners. A model apartment serves as a reference for contractors to carry out the services. Of particular note is the creation of a "technical space" for carrying out piping and necessary inspections. On the facade, a finish was carried out to hide the connection between the slabs and the walls, using cellular blocks to form frames.

Figure 9: Enterprise 2 in the municipality of Blumenau/SC.

Source: own elaboration.

The enterprise 3 in Blumenau consists of a tower with two basements and 13 standard floors, containing eight apartments per floor, each with an area of 63.00 m². The foundations were made with pre-cast piles and metal profiles, and the masonry used concrete structural blocks, channels, compensators, inserts and hydraulic blocks. The materials were tested according to ABNT standards, with quality control during execution. The presence of a professional monitoring the executive procedures to ensure compliance of the work stands out.

Figure 10: Enterprise 3 in the municipality of Blumenau/SC.

Source: own elaboration.

In Enterprise 4, also located in Blumenau, two towers with 12 standard floors were built, containing nine apartments per floor, each with an area of 52.00 m². The foundations were made with Strauss piles, and the masonry used concrete structural blocks, inserts, channels, compensators and "J" blocks. The testing and quality control procedures followed ABNT standards, with an emphasis on the resistance of the materials. Of particular note is the detailed planning of grouting rates per floor and the presence of equipment that contributes to the rationalization of services.

Figure 11: Enterprise 4 in the municipality of Blumenau/SC.

Source: own elaboration.

DIAGNOSIS OF STRUCTURAL MASONRY IMPLEMENTATION

The table 1 summarizes the surveys carried out at structural masonry construction sites in 11 projects located in cities in the states of São Paulo, Paraná and Santa Catarina.

Based on observations made at construction sites in relation to the procedures carried out, it was found that some projects do not fully adhere to the established standards.

It is noteworthy that project 1, located in the city of Jaboticabal-SP, presents the largest number of non-conformities in relation to the construction process, evidenced by:

- Lack of organization at the construction site regarding the arrangement of blocks, which are deposited in direct contact with the ground, mixing block patterns and without adequate reception control, in addition to transporting them using inadequate equipment;
- Irregularities in the laying of the blocks, such as variations in the thickness of the mortar, lack of plumb and leveling the walls;
- Inappropriate use of tools by workers;
- Absence of specimens (prisms and blocks) prepared for tests, as well as reports proving the results of the tests carried out.

Based on the observations made, it is not possible to determine the type of control used in the project in relation to the masonry components.

In project 1 in São José do Rio Preto-SP, the following procedure stands out: Although the preparation of prisms was visualized, reports containing the results of the tests were not presented. Being a project composed of ground floor towers plus 3 floors and with block resistance equal to 4.0 MPa, it is unfeasible to define the type of control used.

As for other projects, it was observed that the executive controls and procedures aim to comply with current standards, with more rigorous monitoring of the execution of services by the construction inspection, with regard to the quality of the masonry and the use of appropriate tools. These projects, generally run by larger companies, have a higher number of towers and floors, which contributes to more efficient control, with component tests carried out more frequently and more comprehensively.

Furthermore, it was found that in all projects there is a need for improvements in executive activities, thus contributing to improving the construction system in structural masonry.

CONCLUSION

The study of block factories revealed practices aligned with the standards of the Brazilian Portland Cement Association (ABCP), demonstrating well-structured manufacturing processes. Most of these factories maintain quality programs certified by bodies recognized by Inmetro, which results in products with reliable physical and mechanical characteristics. In addition, they establish partnerships with construction companies to improve their processes, ensuring compliance with the specifications required by housing program financiers. These practices demonstrate a commitment to quality and efficiency in the production of concrete structural blocks.

The main objective of the research carried out at construction sites in the cities of the states of São Paulo, Paraná and Santa Catarina was to compare executive procedures with ABNT standards, analyzing various aspects of the projects. From the data collected, it was found that there is a predominance of the use of concrete blocks, mainly the 14x19x39 cm and 14x19x29 cm models, with emphasis on the relevance of the grouting activity to ensure adequate filling of the voids in the blocks. As

Analyzed items	Enterprises										
	São Carlos		Londrina	Araçatuba		SJRP	Jabotic.	Blumenau			
	1	2	1	1	2	1	1	1	2	3	4
Masonry	Concrete	Concrete	Concrete	Concrete	Concrete	Concrete	Ceramic	Concrete	Concrete	Concrete	Concrete
Number of towers	2	1	4	1	16	7	1	2	1	1	2
Number of floors	T+12	SS+T+10	T+7	T+7	T+2	T+3	T+3	2SS+14	15	2SS+13	12
Apartment area	65	75	58	86	75	49	65	66	72	63	52
(square meters)	Good	Regular	Good	Regular	Good	Good	Bad	Good	Good	Good	Bad
Construction site	Good	Good	Good	Good	Good	Good	Bad	Good	Good	Good	Bad
Cleaning the work	Piles	piles	piles	Radier	Radier	Piping	Stake	Stake	Stake	Stake	Stake
Foundation	Good	Good	Bad	Good	Good	Good	Good	Good	Good	Good	Good
Modulation	Good	Good	14x19x39	Good	Good	Good	Good	Good	Good	Good	Good
Settlement	14x19x39	14x19x29	No	14x19x29	14x19x29	14x19x39	14x19x29	14x19x39	14x19x39	14x19x39	14x19x39
Basic block	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No
Special blocks	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	No
J Block	No	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes
Compensators	No	No	Yes	No	No	Slabs	No	Slabs	Slabs	Slabs	Slabs
Precast elements	Yes	Yes	Construction	Industrial	Industrial	No	Constructions	Yes	Yes	Yes	Yes
FBK (variation)	Industrial	Industrial	Cleaning	Cleaning	Cleaning	Industrial	Cleaning	Industrial	Industrial	Industrial	Industrial
Mortar	Cleaning	Cleaning	No	No	No	Cleaning	No	Cleaning	Cleaning	Cleaning	Cleaning
Free Points	Cleaning	Yes	Massive	Pre-massive	Pre-massive	No	Massive	Transition	No	Transition	Transition
Pilotis	No	Massive	Yes	Pre	No	Pre-massive	Yes	Pre-massive	Premassive	Pre-massive	Pre-massive
Slab	Massive	No	Pre	No	Pre	Pre	Massive	Yes	Yes	Yes	Yes
Gasket (cover)	Yes	Plaster	Yes	Plaster	No	No	No	Pre	Pre	Pre	Pre
Ladder	Massive		Plaster		Plaster	Plaster	Plaster	No	No	No	No
Internal sheet metal	No							No	Plaster	Plaster	Plaster
Coating											
Masonry Tools											
Trowel	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Palette	No	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
tube	No	No	No	No	No	Yes	No	No	No	No	No
rubber hammer	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Metal ruler	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Template	No	No	No	Yes	Yes	Yes	No	No	No	No	No
Level	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Bob	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Square	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 1: Items analyzed by enterprise.

*f_{bk} (characteristic compressive strength of the block); T (ground floor); SS (underground).

Source: own elaboration.

for slabs, there was a preference for solid and precast slabs, as well as prefabricated stairs. The structure of buildings tends to support the first floor directly on the foundations, although some adopt pilotis or transition structures for basements. An important point is the connection between designers and consultants with academic or research institutions, which contributes to the evolution of the structural masonry construction system. Practices to minimize pathologies were also identified, such as the use of insulating materials at masonry-slab interfaces. As for coverings, plaster is predominant, while companies hired for construction sites tend to select professionals experienced in this construction system. Despite the different geographic regions, no major disparities were observed in the executive procedures and controls carried out in the projects. Of particular note is the mobilization of construction companies, factories and associative entities to promote knowledge and appropriate procedures for structural masonry construction.

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