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Comparative analysis: PVC and concrete panels and traditional masonry

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Abstract
This article presents a comparative analysis between the construction system using PVC panels and concrete and conventional masonry, exploring their advantages and disadvantages in the context of civil construction. The main objective is to assess the feasibility of each method, considering factors such as sustainability, cost, efficiency, and environmental impact. The study was conducted based on a literature review of the mechanical properties of PVC, its resistance to degradation, and its practical applications in various areas of construction. Characteristics such as execution speed, durability, and environmental challenges were also compared. The results indicate that the PVC system offers significant advantages in terms of construction speed, resource savings, and durability. However, it presents challenges such as the emission of toxic gases in fire situations and limited suppliers, which can increase costs. Conventional masonry, although widely used and accessible, faces problems such as waste generation and quality control. It is concluded that both systems have their place in civil construction, and the choice between them should be based on a detailed analysis of the project's needs, considering environmental impacts and long-term costs.

Keywords: civil construction; PVC system; conventional masonry; sustainability.

Análisis comparativo: paneles de PVC y concreto y albañilería tradicional

Resumen
Este artículo presenta un análisis comparativo entre el sistema constructivo utilizando paneles de PVC y concreto y la mampostería convencional, explorando sus ventajas y desventajas en el contexto de la construcción civil. El objetivo principal es evaluar la viabilidad de cada método, considerando factores como la sostenibilidad, el costo, la eficiencia y el impacto ambiental. El estudio se llevó a cabo en base a una revisión de la literatura sobre las propiedades mecánicas del PVC, su resistencia a la degradación y sus aplicaciones prácticas en diversas áreas de la construcción. También se compararon características como la velocidad de ejecución, la durabilidad y los desafíos ambientales. Los resultados indican que el sistema de PVC ofrece ventajas significativas en términos de rapidez de construcción, ahorro de recursos y durabilidad. Sin embargo, presenta desafíos como la emisión de gases tóxicos en situaciones de incendio y la limitación de proveedores, lo que puede aumentar los costos. Por otro lado, la mampostería convencional, aunque ampliamente utilizada y accesible, enfrenta problemas como la generación de residuos y el control de calidad. Se concluye que ambos sistemas tienen su lugar en la construcción civil, y la elección entre ellos debe hacerse en base a un análisis detallado de las necesidades del proyecto, considerando los impactos ambientales y los costos a largo plazo.

Palabras clave: construcción civil; sistema de PVC; albañilería convencional; sostenibilidad.

1 Introduction

The growing demand for adequate infrastructure in Brazil has driven the search for innovative solutions that overcome the challenges of traditional construction methods, such as high cost, long execution time, the need for specialized labor, and significant environmental impact [12]. In this context, the use of PVC and concrete panels emerges as a promising alternative.

The construction system using PVC and concrete panels proves to be more sustainable than traditional methods. The panels are produced from recycled materials, reducing water and energy consumption during construction [27].

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Additionally, they are highly durable and resistant to weather, fire, insects, and fungi, ensuring a long lifespan for the construction [1].

This construction system can also significantly reduce the total cost of the project compared to traditional methods due to the speed of assembly, the reduced need for specialized labor, and the optimization of material use [19]. The assembly of the prefabricated panels is quick and easy on the construction site, considerably reducing execution time [30].

Regarding electrical and plumbing installations, they follow conventional standards and are directed vertically. The pipes are inserted from the top of the wall or from the concrete base, running an internal path within the panels to accommodate different circuits. The construction process is organized into five stages: infrastructure, superstructure, roofing, finishes, and installations [32].

These objectives aim to provide a comprehensive overview of the advantages and disadvantages of construction systems using PVC and concrete panels compared to traditional masonry methods, contributing to informed decisions regarding the adoption of more efficient and sustainable construction technologies.

2 Construction system with PVC and concrete panels in civil construction

The concept of a construction system can be understood as a procedure that encompasses various levels of industrialization and organization, integrating a set of interrelated components into the construction process [28]. In the context of innovative systems, it is essential that they are based on technical qualifications related to the materials and components used, in order to meet the needs of users and the purpose of the space. Additionally, it is crucial to find efficient cost/benefit solutions, especially regarding social aspects. Fig. 1 Illustrates the cross section of the panels and the reinforcement, highlighting the integration of materials and structural elements in the construction system.

For the progress of a society, as highlighted by [25], it is essential not only to encourage the research and development of new technologies but also to establish access channels for the effective implementation of these innovations in production environments. Therefore, the next stage of this research is dedicated to the study of the concrete-PVC system, exploring theoretical references and the main contexts of application of this technology. The system, composed of structural concrete walls with integrated PVC profiles, demonstrates high productive efficiency, even when operated by a small team. These profiles are fitted together to function as concrete forms, as well as serving as cladding and final finish. This technology is primarily applied in singlestory houses and two-story houses, resulting in walls of varying thicknesses. The thickness of the PVC profile used varies according to structural loads, installations, and the manufacturer's production specifications [7]. The different modular profiles are connected through a double male and female interlock.

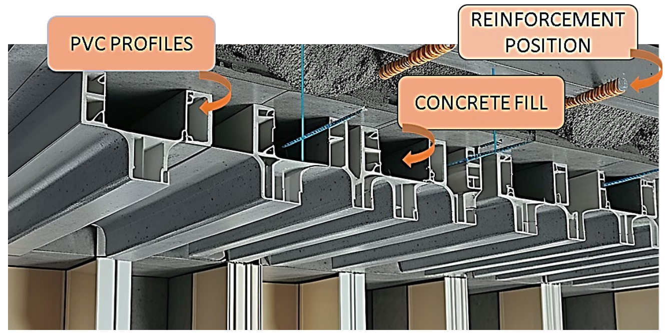

Figure 1. Illustration of the cross section of the panels and the reinforcement.
Source: Author's own work.

A pioneering example in the country was the construction of 151 houses in the municipality of São Luiz do

Paraitinga/SP in 2010, aimed at sheltering families displaced by a flood. The housing complex in São Paulo was completed

after months of work. According to the Brazilian Portland Cement Association [1], which provided technical guidance for the construction, the advantages include the speed of execution, the absence of waste, and the high durability of the materials used.

Fig. 2 Illustrates a city with the basic module system of 64 mm and 100 mm. The system developed by Royal Group Technologies Limited operates through double interlocking modular profiles that are assembled vertically during construction. For the implementation of the walls, panels of different thicknesses are used: 22 mm, 64 mm, 100 mm, and 150 mm, with the latter recommended for extreme climates. The use of panels with thicknesses of 100 mm and 150 mm allows this method to be applied in the construction of buildings with different standards and purposes, such as industrial, institutional, commercial, and residential buildings of up to five stories (ground floor plus four floors) [15]. The use of structural concrete is essential, although conventional structures such as beams and columns are not necessary [26].

Initially, the site is cleared, followed by the excavation of trenches according to the alignment of the future walls. After excavation, boards are installed for framing and leveling the forms intended for concreting. It is recommended to apply a 100-micrometer polyethylene film over the entire surface of

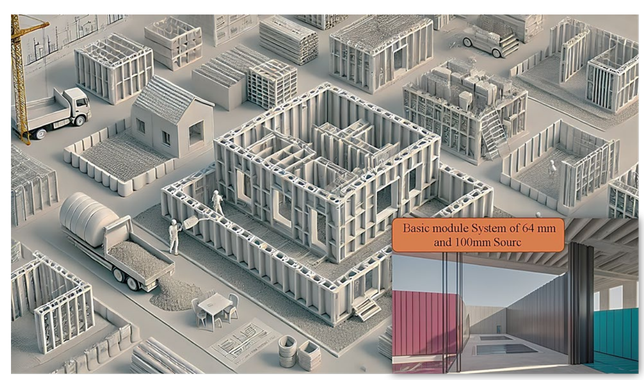

Figure 2. Illustrates a city with the basic module system of 64 mm and 100 mm.
Source: Author's own work.

the slab to ensure its waterproofing. Next, a 2.5 cm layer of gravel is added to the top of the slab, above the trenches, to serve as support for the steel bars [26].

The concrete-PVC system allows for the use of more compact foundations, such as continuous footings or strip footings. Particularly recommended is the implementation of a raft foundation, due to the speed of execution and the immediate availability of the subfloor upon completion of the foundation, resulting in a significant reduction in construction time [13].

All water and sewage points and pipes for the construction should be planned. With all previous steps completed, the concreting of the slab begins. The concrete used must have a minimum strength of 15 MPa at 28 days. During execution, it is crucial to observe to avoid unevenness in the final surface, as any irregularity in the height of the slab is reflected in the top of the PVC profiles, which are already pre-cut at the factory [13].

In cases of using other forms of foundation, such as continuous footings or strip footings, it is necessary to fill the subfloor to align it with the perimeter beams. To optimize water drainage, it is recommended to apply an internal subfloor of at least 20 mm, along with creating a sloped gradient between the external sidewalk and the structure [26].

The use of this technology does not require heavy equipment or special tools. The walls are anchored to the foundation through vertically positioned steel bars or metal channels fixed to the foundation, depending on the manufacturer's specifications. The PVC profiles are individually or collectively attached, sliding from top to bottom into the channels. In accordance with the design, vertical reinforcements are essential to strengthen the joints of the vertical walls and on the sides of doors and windows. Electrical and plumbing installations should be positioned internally to the enclosure, using specific pipelines (Fig. 3). It is crucial to position templates in the openings precisely to avoid concrete losses. From the concreting, a monolithic wall is formed, making the use of conventional fluid or selfcompacting concrete recommended for complete filling of the forms without the need for vibration [7].

Polyvinyl chloride, a synthetic polymer derived from sodium chloride and petroleum derivatives, is composed of long-chain molecules containing repeated monomers that are bonded through strong bonds. These molecules form a threedimensional network held together by considerably weaker secondary bonds [10].

In terms of composition, PVC is made up of approximately 57% chlorine and 43% ethylene, a petroleum derivative [18]. The manufacturing process of PVC involves obtaining chlorine through the electrolysis of sodium chloride, which reacts with ethylene, both in the gas phase, forming a gas. This gas, when subjected to heat, transforms into the molecule vinyl chloride monomer. Subsequent polymerization results in polyvinyl chloride, presenting itself as a very fine white powder and inert.

The polymerization of PVC is classified as addition polymerization since there is no loss of parts of the molecule. Consequently, this material is designated as thermoplastic, allowing it to be heated, cooled, molded, and reheated without losing its initial physical properties. This characteristic facilitates its reshaping through combinations of pressure and temperature, contributing to ease of recycling [10]. The general physical and chemical characteristics of PVC can be found in Table 1.

Table 1.
Main Properties of PVC.

Main properties of rigid PVC	
Average molecular weight: 20,000 to 150,000 g/mol	Melting temperature: 273°C
Specific mass: 1.40 g/cm³	Glass transition temperature: 87°C
Tensile strength: 31-60 MPa	Specific heat: 0.8 - 0.9 J/ºC

Source: Source: Author's own work.

[2] describes PVC as a material for civil construction that stands out for its versatility and durability, mentioning that, in certain cases, PVC components used in civil construction can have a lifespan of up to 50 years.

PVC (polyvinyl chloride) is one of the most widely used thermoplastics globally, as highlighted [11]. Its global demand in 2005 exceeded 35 million tons, highlighting its importance in the industry. In Brazil, PVC consumption represented about 2% of the total global demand that year, a relatively modest share compared to more industrialized countries such as China, which held a 20% share, and Japan, with 5% of global consumption.

These data underscore the significant presence and applicability of PVC in different sectors, including civil construction, packaging, healthcare, among others. In the context of civil construction, PVC is valued for its versatile properties such as durability, strength, ease of handling, and low cost, making it a common choice for a variety of applications, including innovative construction systems as mentioned in the research.

Royal Building Systems indicates that for single-story residences, any type of concrete can be used in this system. However, to ensure greater economy and performance in construction, the use of lightweight concrete is recommended. For multi-story residences, the guidance is to use structural concrete with a strength between 8 to 15 MPa and with a minimum Slump of 18 cm [26].

PVC also demonstrates remarkable tensile strength, evaluated at around 42 MPa [2], a significantly higher value compared to reinforced concrete, which has approximately 2 to 3 MPa [21].

The profiles constitute an essential part of a comprehensive construction system, with each piece meticulously identified by its height and type. Each of these pieces is strategically positioned within the previously planned layout. To determine the position of each panel, a set of plans is provided for each step of the work. Among these plans, one is dedicated to the precise identification and location of each profile. Additionally, in supplying the PVC kit for the project, pre-assembled lintels and sills for windows and doors are included, which are also meticulously identified and characterized in the engineering drawings [26].

To ensure efficient assembly, all panels are properly identified with labels or markings painted on the inner and upper part of each one. During the assembly process, the correct position of each panel is with the label or marking facing upwards. To reduce time on-site and improve the efficiency of the workers, it is advisable to distribute the panels according to their location, meaning that all panels related to a wall should be placed near the corresponding assembly area [26].

The construction system with PVC and concrete panels represents an innovative approach in civil construction, offering a series of advantages over traditional methods. However, it also faces significant challenges that need to be addressed for its broader and more effective adoption. In this topic, both the advantages and challenges associated with this construction system will be explored.

The method involves the use of lightweight PVC panels manufactured in industries, which are easily manually fitted. The height of the profiles is determined during the project, and these panels can have various thicknesses. The modules are internally filled with concrete and structural Steel [6]. This construction system is characterized by rapid execution and offers notable advantages, especially due to PVC being used as both internal and external cladding. Watertightness, weather resistance, and long durability stand out as some of the advantages of this construction method [17].

Sustainability is one of the most striking advantages of the PVC and concrete construction system. The durability of PVC panels significantly contributes to reducing the environmental impact of construction by extending the building's lifespan, thus reducing the need for frequent material replacement. This not only minimizes resource waste but also decreases the amount of waste generated during the building's lifecycle [23].

Furthermore, the reduction of waste production during construction is an additional benefit of this construction system. The prefabrication of PVC panels allows for a cleaner and more organized construction process, maintaining a tidier and safer working environment for workers. This reduction in waste generation not only contributes to environmental preservation but also simplifies other stages of construction, such as site cleanup and waste management [17].

Another relevant point is the reduction in the use of natural resources, such as water, during construction. The use of prefabricated PVC and concrete panels can significantly decrease water consumption compared to conventional construction methods since it reduces the need for mortar and concrete preparation on-site. This saving of water resources is crucial in regions where water availability is limited or where water sustainability issues are a growing concern [14,12].

Therefore, the sustainability offered by the PVC and concrete construction system not only benefits the environment but also provides operational and economic advantages, promoting more responsible and efficient construction practices.

Another positive aspect of the PVC and concrete system is the speed of construction since the prefabrication of panels allows for quick and efficient assembly on-site, resulting in a significant reduction in construction time compared to traditional methods. This efficiency in panel assembly on-site results in a significant reduction in construction time compared to traditional methods. In many cases, building construction using this system can be completed in a substantially shorter period, which not only speeds up project delivery but also allows owners to start using the space more quickly, generating additional economic benefits [14]. Fig. 3. PVC and concrete system at the Municipal School Mônica de Fátima Meireles Pessoa in Valparaíso de Goiás. The image was taken on-site, showcasing the implementation of this construction method.

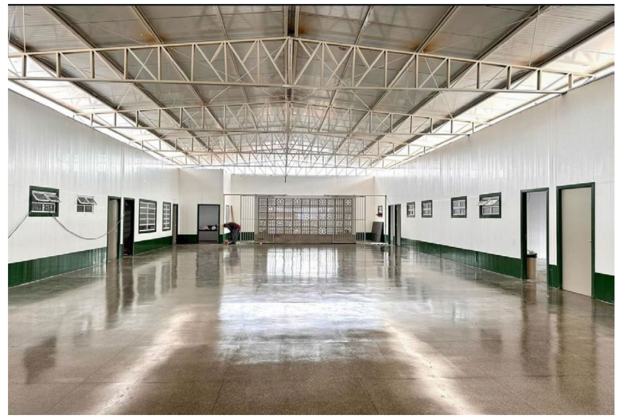

Figure 3. PVC and concrete system at the Municipal School Mônica de Fátima Meireles Pessoa in Valparaíso de Goiás.
Source: Author's own work.

Moreover, the speed of construction also has a positive impact on overall project costs, as the reduction in construction time is directly related to a decrease in labor and financing costs. This can make the PVC and concrete construction system a more attractive option for investors and developers looking to maximize return on investment and minimize risks associated with project completion delays [14].

Thus, the construction speed offered by this system not only represents an advantage in terms of schedule and operational efficiency but also can have significant positive impacts in terms of cost and project financial viability. This characteristic makes the PVC and concrete construction system an attractive choice for a wide range of applications in civil construction.

The use of PVC in construction offers several advantages, such as tensile strength, flexibility, and lightness. However, it is essential to consider the environmental and public health impacts related to the material's lifecycle, especially during its disposal or when exposed to high temperatures. When PVC is burned, it releases toxic substances like dioxins, which are highly harmful to human health and the environment. These dioxins, along with other released chemicals, are persistent pollutants, bioaccumulative, and have potentially carcinogenic effects. Moreover, exposure to these compounds can cause disruptions to the endocrine and immune systems, severely impacting public health (Rodrigues, 2010; Nakamura, 2024).

The incineration of PVC in landfills or accidental combustion during building fires also poses significant risks to air quality, contributing to atmospheric pollution with toxic substances. Therefore, proper waste management of PVC is crucial, requiring stricter recycling and disposal policies to minimize harmful impacts on the environment and health (Acetoze, 1996; Petrucci, 1983).

The development of alternatives to PVC in construction, such as the use of less toxic materials or technological solutions that reduce the release of hazardous substances, could be an important pathway. Additionally, implementing more effective recycling practices is fundamental to reducing the risks associated with improper disposal (Silva, 2003; Júnior et al., 2006).

However, the PVC and concrete system presents challenges and some disadvantages compared to the traditional system. [17] explains that despite its ease of use, in the Brazilian context, the PVC and concrete system faces a significant limitation due to the scarcity of suppliers. This scarcity results in a limited supply of materials and services related to the PVC and concrete construction system, which, in turn, increases the product's value in the market. The price can be up to 20% higher than that of conventional masonry.

This lack of competition among suppliers can be attributed to various factors, such as the complexity of PVC and concrete panel production, the lack of government incentives for the development and dissemination of this construction system, and the historical preference for conventional construction methods. As a result, although the system offers significant benefits such as durability, safety, and construction speed, its high cost may represent an obstacle to its wider adoption in the Brazilian market.

3 Conventional construction system

All According to [16], conventional masonry is a construction system with ancestral origins, arising from the simple arrangement of materials to achieve a specific goal. This method found success over time, possibly due to a more stable economy and increasing competitiveness in the market. These factors drove the need to develop additional elements and strategies to address issues not previously considered by masonry.

Conventional construction systems, involving ceramic masonry walls or concrete blocks and concrete structural bases, have been widely used for thousands of years, recognized as safe and reliable construction methods. Conventional masonry is a construction system in which the structure's load is mainly supported by slabs, beams, columns, and foundation. In this method, walls do not have a structural function, being called non-load-bearing, and are used only to close openings and divide spaces [31].

For a long time, walls played a structural role in constructions, acting as an extension of the foundation and assuming the functions of columns and beams. This implied that walls could not be easily removed, significantly limiting renovation options. Additionally, a common challenge faced by old buildings was the additional weight that walls exerted on foundations [9].

However, with the advancement of modernism and progress in civil construction, structures began to be conceived independently of walls, which came to be known as curtain walls as well. This change represented an important innovation introduced by architects and engineers as early as the 19th century and continued to evolve throughout the 20th century [14].

According to [31], the essential element in conventional masonry construction is the brick, also known as ceramic block. This material is made from clay, which acquires a reddish hue after being subjected to high temperatures during the ceramic block manufacturing process.

According to [9] highlight that conventional masonry, also known as curtain walling, is widely used in the country due to its versatility, being able to be employed in a variety of projects, including large buildings. As it does not have a structural function, walls of conventional masonry are adaptable for the passage of hydraulic and electrical systems, providing architectural flexibility and ease of layout alteration, without the need for strict quality control in the choice of materials or in the execution of labor.

This type of masonry employs ceramic blocks with vertical holes, characterized by their low resistance compared to structural masonry blocks. As established by NBR 15270:2005, the compression strength of these blocks is 1.5 MPa [8].

Masonry, whether for curtain walls or structural purposes, is composed of natural stones, bricks, or concrete blocks, aiming to provide strength, durability, and impermeability. Bricks, especially fired clay bricks, are the most commonly used, being manufactured from clay mixed with sand. After the clay selection, the paste is molded and fired in kilns at temperatures between 900 and 1100 °C, resulting in bricks of various shades, depending on the quality of the clay used. The quality of the brick can be checked by the sound test, where a well-fired brick produces a specific sound and has a uniform color and defined edges [31].

In order to improve the speed and quality of masonry execution, the process has been divided into sub-stages, following the technical guidelines established by NBR 8545 (Execution of Masonry without structural function of bricks and ceramic blocks), in order to avoid future pathologies. These sub-stages include marking, laying, and shimming, and it is essential to respect the technical deadlines for the completion of each stage, in order to guarantee the integrity of the masonry [29].

Thus, the architectural flexibility provided by conventional masonry, combined with its adaptability for the passage of hydraulic and electrical systems, demonstrates its versatility and applicability in a variety of projects.

In conventional civil construction, the construction stages follow a sequential process involving several phases from the beginning to the completion of the work. Generally, this process is divided into distinct stages to facilitate planning, execution, and quality control.

The infrastructure constitutes the part of the construction located below ground level, where the foundations are located responsible for transmitting loads to the soil, requiring adequate strength to withstand external loads [33]. According to NBR 6122:2022 [4], foundations are categorized as deep, which transmit loads by lateral friction, and shallow, known as shallow foundations.

As explained [5], a foundation is the fundamental structure of a building, responsible for supporting the building's loads and distributing them to the soil. This base can be categorized as shallow or deep and includes elements such as rafts, foundation beams (strip footings), footings, blocks, associated footings, among others.

The superstructure represents the portion of the building located above ground level. In this part, loads are transferred through beams and columns, ensuring the structure's stability. Beams support vertical loads and predominantly bend within the system. They also serve as support for slabs, which unload their loads onto the beams, and these, in turn, transmit the loads to the columns. The latter have the function of absorbing the vertical loads from the floors (Adapted [32]; [3] Fig. 4. Conventional Construction System. This figure illustrates the relationship between the foundation and the superstructure of a building.

For the execution of masonry, it is essential to have a complete architectural design, especially in the cross-sectional and floor plan drawings, where the dimensions to be followed during masonry construction are presented. According to [24], the procedure for executing internal and external enclosures involves several steps. Initially, it is necessary to mark the masonry modulation, starting from the corners and then marking the first row with bricks aligned in mortar. It is advisable to designate a qualified mason for this task, ensuring productivity and quality.

The construction of corners must be done with attention to leveling, perpendicularity, plumbness, and joint thickness, as they will serve as a reference for the entire work. It is important to stretch a line as a guide to ensure the correct verticality and horizontality of the rows. Each laid brick must be checked for plumbness. Vertical joints should be staggered between consecutive rows to ensure masonry stability.

As highlighted [20], during masonry execution, it is essential to observe various details: The mortar joints should have a thickness between 1.0 and 1.5 cm. Over door and window openings, lintels should be installed, which can be small wooden or concrete beams, designed to resist the masonry forces on these openings. It is important to note that wooden lintels should not be used in openings larger than 3 m or for metal frames. Concrete lintels can be precast or cast in place, should have a minimum height of 10 cm, and a width corresponding to the wall thickness.

Figure 4. Conventional Construction System.
Source: Author's own work.

In the case of constructions with an independent reinforced concrete structure, when raising the wall, it is necessary to leave a space of approximately 20 cm between the last row of bricks and the beam. This space must be filled with solid bricks laid inclined, in a procedure known as "wall tightening." This technique aims to compress the masonry raised against the concrete structure, avoiding the appearance of shrinkage cracks in the masonry. After approximately seven days of mortar curing, it is possible to perform the "masonry tightening." When one wall meets another, it is necessary to "tie" them together to avoid cracks at this junction [20].

The type of coating used varies according to the installation area. In areas subject to humidity, such as bathrooms, kitchens, service areas, and outdoor spaces, it is essential to carry out adequate waterproofing to prevent future problems [31].

According to [34], the ceiling consists of a protective or coating layer applied to the internal parts of the roofing structure, directly influencing the thermal and acoustic comfort, as well as the aesthetic aspect of the construction. The author emphasizes the importance of selecting suitable materials and elements for making the ceiling, as each requires specific installation methods. For example, in simpler residences, it is common to find ceilings made of wood or PVC.

The main purpose of the ceiling is to contribute to the aesthetic of the architectural environment while providing protection and offering acoustic and thermal insulation. A variety of materials can be used in ceiling construction, such as plaster, wood, metal, and PVC, among others. The choice of ceiling type should prioritize harmony with functionality and space comfort, also considering whether the lighting will be recessed and if the ceiling will contribute to improving thermal and acoustic comfort for occupants [5].

Before applying the floor covering, it is essential to ensure that the surface is level and properly waterproofed. The laying process follows a similar approach to that used for coating walls with ceramic tiles, using mortar and finishing with grout. There are several flooring options available, such as burnt cement, wood, stone, and the traditional ceramic tile floor, which is widely used [31].

Despite the importance of conventional construction systems, these traditional methods also have some disadvantages in terms of structural pathologies, economic issues, and environmental impacts [22]. In terms of quality, although conventional masonry is widely accepted by users and offers flexibility for changes and renovations in buildings, quality control can be compromised due to artisanal processes, often resulting in rework. Additionally, the quality of the raw materials used can vary, affecting the durability and strength of the structure [33].

Quality control is a crucial aspect in any construction project. In the case of conventional masonry, artisanal processes can pose a challenge to ensuring consistent quality standards, resulting in variations in execution and potential errors throughout construction. As a consequence, rework to correct these issues is common, increasing project costs and timelines. Additionally, the quality of the raw materials used in masonry can vary significantly, impacting the durability and strength of the structure [34].

Regarding performance, conventional masonry generally exhibits high resistance and the capacity for large spans, which is a significant advantage. However, over time, pathologies such as cracks, fissures, and moisture may appear in conventional masonry, compromising its structural and aesthetic integrity. Additionally, the high self-weight of the structure can increase demands on foundations and affect overall stability [5].

In terms of maintenance, although costs are generally low, execution can be challenging due to significant material wastage and the need for specialized labor, which can increase costs [31,5].

In the environmental aspect, conventional masonry does not offer significant advantages, with high waste generation being a major disadvantage. This waste can pose a significant environmental problem, contributing to soil pollution and overloading landfills. Additionally, the production of construction and demolition waste has a negative impact on the use of natural resources and the carbon footprint associated with the construction industry [8].

In terms of cost, although conventional masonry generally stands out for the affordability of materials and labor, a large volume of labor is required, and material wastage can be a problem, affecting the total project cost.

4 Mechanical properties of PVC compared to other construction materials

For a comprehensive analysis between different construction systems, it is essential to compare the mechanical properties of the materials involved, such as PVC, concrete, and masonry. Below, a table compares tensile strength, modulus of elasticity, density, and the behavior of these materials under extreme temperatures, providing a clearer view of the advantages and limitations of each. Table 2. Comparison of Properties of PVC, Concrete, and Masonry (Ceramic).

Tensile Strength: PVC demonstrates a relatively high tensile strength compared to concrete and ceramic masonry, making it suitable for applications where lightness and durability are desired, but without the need to support large loads [2,21].

Modulus of Elasticity: In terms of stiffness, PVC has a lower modulus of elasticity than concrete, making it more flexible but less resistant to deformation under load. This is a limiting factor in constructions that require structural rigidity [11,31].

Table 2.
Comparison of Mechanical Properties between PVC, Concrete, and Masonry

Property	PVC	Concrete	Masonry (Ceramic)
Tensile Strength	31-60 MPa	2-5 MPa	1-1.5 MPa
Elastic Modulus	2.5-4 GPa	30-40 GPa	2-6 GPa
Density	1.40 g/cm³	2.4 g/cm³	1.8-2.0 g/cm³
Behavior at Extreme Temperatures	Resists up to 60-80°C, begins to melt above this	Resists up to 1000°C	Resists up to 900-1100°C

Source: Adapted from Acetoze (1996), Petrucci (1983), Júnior et al. (2006), Rodrigues (2010), Nakamura (2024), Silva (2003), Gorninski & Kazmierczak (2007).

Density: The density of PVC is significantly lower than that of concrete, making it lighter and consequently easier to transport and assemble in construction. However, this lightness results in lower structural strength, requiring the addition of reinforcements, such as reinforced concrete in composite systems [12,10].

Behavior in Extreme Temperatures: PVC has a clear disadvantage when exposed to high temperatures, beginning to deteriorate around 60-80ºC and emitting toxic fumes when burned. Concrete and ceramic masonry, on the other hand, are highly resistant to extreme temperatures, making them safer in the event of a fire [25,15].

5 Conclusion

This comparative analysis highlights the distinct advantages and challenges presented by the PVC and concrete system versus traditional masonry in civil construction. The PVC and concrete system offer notable benefits in terms of construction speed, sustainability, and resource efficiency. Its modular nature and ease of assembly provide significant operational advantages, reducing overall project time and costs. Additionally, the durability of PVC contributes to reducing environmental impacts over the building's lifecycle, enhancing its appeal for long-term use.

However, this system is not without its challenges. One of the major concerns is the environmental and health risks associated with the disposal or burning of PVC, which can release harmful dioxins and other toxic substances. Furthermore, the scarcity of suppliers and the potentially higher costs in some regions limit the system's widespread adoption, particularly in the Brazilian market.

On the other hand, traditional masonry, though widely accepted and cost-effective, poses its own challenges, such as waste generation, slower construction times, and quality control issues. Nonetheless, it remains a reliable and adaptable construction method, particularly suited for projects requiring flexibility and ease of renovation.

Ultimately, the decision between these two construction systems should be based on the specific needs of each project, taking into account factors like sustainability, cost, durability, and environmental impact. Both systems play a crucial role in modern civil construction and can be effectively employed depending on the priorities and requirements of the project.

References

[1] ABCP., Alvenaria estrutural: guia técnico. Associação Brasileira de Construção Predial, Brasil, 2013.

[2] Acetoze, A.L., Manual trikem de produtos de PVC utilizados na construção civil. São Paulo: Pini, 1996.

[3] Associação Brasileira de Cimento Porthland. ABPC auxilia regiões devastadas pelas enchentes. [online]. 2011. Available at: https://www.abcp.org.br/conteudo/tag/concreto-pvc

[4] NBR, ABNT. 6122: Projeto e execução de fundações. Rio de Janeiro, 2010, 91 P.

[5] Cassar, B.C., Análise comparativa de sistemas construtivos para empreendimentos habitacionais: alvenaria convencional x light steel frame. Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil, 2018.

[6] Chanan, L.A., Análise comparativa de custos de uma residência unifamiliar executada com método construtivo convencional e concreto-PVC. 2017.
[7] Cichinelli, G., Sistema construtivo para casas e sobrados usa painéis de PVC preenchidos com concreto. Revista Téchne, São Paulo, 199, pp. 31- 34, 2013.
[8] Gonçalves, L.S., Cazella, P.H. da S., Agiado, A.C., and Pedreiro, M.R.deM., Análise comparativa entre alvenaria convencional e alvenaria estrutural. Revista Ibero-Americana de Humanidades, Ciências e Educação, 8(11), pp. 2611–2618, 2022. DOI: https://doi.org/10.51891/rease.v8i11.7851
[9] Gonzaga, A., EPS para construção civil: vantagens e desvantagens. Papo de Engenheiro. [online]. [Acesso em: 28.04.2024]. Disponível em: https://www.orcafascio.com/papodeengenheiro/eps-na-construcaocivil/
[10] Gorninski, J., and Kazmierczak, C., Microestrutura dos polímeros. In: ISAIA, G. C (Org), Materiais de construção civil e princípios de ciências e engenharia dos materiais. São Paulo, SP. IBRACON, v.1, 2007, pp.352-375.
[11] Júnior, A.R., Nunes, L.R., and Ormanji, W., Tecnologia do PVC. 2ª, ed. São Paulo: Braskem, 2006.
[12] Lira, G.K. de S., Estudo do emprego do sistema construtivo em concretoPVC em habitações de interesse social / Glacyelle Kawanna de Sousa Lira. Pombal, 2022.
[13] LTDA, T.E E. Target Normas: ABNT NBR 17077 NBR17077, Paredes estruturais. Disponível em: <https://www.normas.com.br/visualizar/abnt-nbrnm/13584/nbr17077-paredes-estruturais-constituidas-por-paineis-depvc-preenchidos-com-concreto-para-a-construcao-de-edificacoesprojeto-execucao-e-controle-requisitos-e-procedimentos>. Acesso em: 01 jun. 2024.
[14] Meireles, G.L., Comparação de desempenho entre distemas construtivos: alvenaria convencional, estrutura de metal com fechamento em PVC e paredes 100% PVC para canteiro de obras. Trabalho de Conclusão de Curso, Graduação em Engenharia Civil, Departamento de Engenharia Civil, Universidade Federal do Rio Grande do Norte, Natal, 2023.
[15] Nakamura, J., Construção plástica. Revista Techne, São Paulo, ed. 205, pp. 28-32.
[16] Nascimento, A.M., A segurança do trabalho nas edificações em alvenaria estrutural: um estudo comparativo. Dissertação de mestrado. Universidade Federal de Santa Maria, Rio Grande do Sul, Brasil, 2007.
[17] Nascimeto, M.L.S.do., Sistemas construtivos inovadores: evolução e principais materiais, Monografia graduação, Curso de Ciência e Tecnologia, Universidade Federal Rural do Semi-árido, Brasil, 2022.
[18] Nunes, L.R., et. al., Tecnologia do PVC, Braskem. Pro Editores Associados Ltda. 2a, São Paulo, Brasil, 2006.
[19] Nunes, R.C., and Nunes, A.C., A industrialização da construção civil: desafios e perspectivas para o Brasil. Revista Brasileira de Engenharia de Produção, 10(2), pp. 203-215, 2019.
[20] Penteado, P.T., and Marinho, R.C., Análise comparativa de custo e produtividade dos sistemas construtivos: alvenaria de solo-cimento, alvenaria com blocos cerâmicos e alvenaria estrutural com blocos de concreto na construção de uma residência popular. BSc. Thesis. Universidade Tecnológica Federal do Paraná, Brasil, 2011.
[21] Petrucci, E.G.R., Concreto de cimento Portland. 10ª ed. Editora Globo, Porto Alegre, Rio de Janeiro, Brasil, 1983.
[22] Queiroz, R.C., Introdução à engenharia civil: noções sobre a história, importância, principais áreas, atribuições e responsabilidades da profissão. [livro eletrônico]. –Blucher, São Paulo, Brasil, 2019.
[23] Rocha Jr., W., Análise comparativa entre os métodos construtivos de execução de vedações verticais com concreto moldado e executado in loco e convencional com blocos cerâmicos. Trabalho de Conclusão de Curso, Graduação em Engenharia Civil, Centro de Tecnologia, Universidade Federal do Rio Grande do Norte, Natal, Brasil, 2022, 53P.
[24] Rodolfo Jr., A., Nanocompósitos de PVC, argila organicamente modificada e óxidos metálicos: estudo do processo de preparação e propriedades de combustão e emissão de fumaça. Tese Doutorado em Engenharia, Universidade Estadual de Campinas, Campinas, SP, Brasil, 2010.
[25] Rodrigues, A.R., Nanocompósitos de PVC, argila organicamente modificada e óxidos metálicos: estudo do processo de preparação e propriedades de combustão e emissão de fumaça. Tese de Doutorado, UNICAMP, Brasil, 2010.
[26] Rogers, E.M., Diffusion of innovations. New York, 12, 1995, 576P.
[27] Royal do Brasil Technologies. Montagem passo a passo do Sistema RBS – 64. [online]. 2010. Disponível em: https://www.royalbrasil.com.br
[28] Royal Market Ltda., Análise do ciclo de vida do sistema construtivo em PVC e concreto. Relatório técnico, 2018.
[29] Sabbatini, F.H., Desenvolvimento de métodos, processos e sistemas construtivos – formulação e aplicação de uma metodologia. Tese Doutorado em Engenharia, Pós- Graduação em Engenharia Civil, Escola Politécnica da Universidade de São Paulo, São Paulo, Brasil, [online]. 1989, 321P. [Acesso em: fevereiro 2024]. Disponivel em: https://www.pec.poli.br/conteudo/bibliografia/_TeseSabbatini%202007- v5%20(1).pdf.
[30] Santos, E.B., Estudo comparative de viabilidade entre alvenaria de blocos cerâmicos e paredes de concreto moldadas no local com fôrmas metálicas em habitações populares. Campo Mourão, Brasil, 2013.
[31] Silva, M.A. da, Análise comparativa de sistemas construtivos para habitação popular: estudo de caso em Belo Horizonte. Dissertação de Mestrado, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brasil, 2003.
[32] Silveira, G.G., Estudo comparativo entre o sistema construtivo convencional e o sistema construtivo em EPS. RECIEC Revista Científica de Engenharia Civil. 5(2), 2022.
[33] Souza, M.I., and Murta, M.M., Patologias, recuperação e reforço estrutural em concreto armado, 2012.
[34] Villar, F.H.R., Alternativas de sistemas construtivos para condomínios residenciais horizontais: estudo de caso. Dissertação apresentada ao programa de pós-graduação em construção civil. Universidade Federal São Carlos, Brasil, 2005.
[35] Yazigi, W., A técnica de edificar, 10ª ed., Editora Pini, São Paulo, Brasil, 2009.

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