ENGINEERING.
IMPACTO CIENTÍFICO EDITORA

SUSTAINABLE CONSTRUCTION IN THE CONTEXT OF CIVIL ENGINEERING

10.56238/edimpacto2025.023-002

Marcos Cruz de Azevedo[1], Raphael Pacheco da Rocha[2], Sidnei Castilhos Rodrigues[3], Ronaldo Paulucci de Assis[4], Telmo Viana Rodrigues[5], Paulo Alex Nacif Lube[6], Erick de Sousa Marouço[7], Carlos Rogério Domingos Araujo Silveira[8]

ABSTRACT
Civil construction plays a key role in economic development, but it is also responsible for significant impacts on the environment. This study addresses sustainable construction in the

[1] Dr. in Humanities, Cultures and Arts
Brazilian Institute of Rehabilitation Medicine - IBMR
E-mail: marcos.cruz.azevedo@gmail.com
Orcid: https://orcid.org/0000-0001-8586-8543
Lattes: http://lattes.cnpq.br/3059505401829733
[2] Dr. in Production Engineering
Iguaçu University - UNIG
E-mail: raphaelrocha@gmail.com
Orcid: https://orcid.org/0000-0003-3653-1316
Lattes: http://lattes.cnpq.br/6364348869926817
[3] Dr. in Humanities, Cultures and Arts
Iguaçu University - UNIG
E-mail: sidneicr@gmail.com
Orcid: https://orcid.org/0009-0000-1187-8044
Lattes: http://lattes.cnpq.br/0689841175121715
[4] Master in Environmental Sciences
Iguaçu University - UNIG
Email: Ronalassis@gmail.com
Orcid: https://orcid.org/0000-0002-6932-5925
Lattes: https://lattes.cnpq.br/9588790019129910
[5] Master in Mechanical Engineering and Materials Technology
Iguaçu University - UNIG
E-mail: telmoviana@gmail.com
Orcid: https://orcid.org/0000-0001-7626-3243
Lattes: https://lattes.cnpq.br/7466104544085460
[6] Master in Local Development
Iguaçu University - UNIG
Email: paulolube@gmail.com
Orcid:: https://orcid.org/0000-0003-1077-5507
Lattes: http://lattes.cnpq.br/5117121594850582
[7] Master in Mechanical Engineering and Materials Technology
Iguaçu University - UNIG
E-mail: emarouco@gmail.com
Orcid: https://orcid.org/0009-0003-1351-3227
Lattes: http://lattes.cnpq.br/0934512224205362
[8] Master in Local Development
Iguaçu University – UNIG
E-mail: carlosrogerio18@hotmail.com
Orcid: https://orcid.org/0009-0004-1924-9153
Lattes: http://lattes.cnpq.br/9856489582272731

context of civil engineering, discussing strategies to reduce the consumption of natural resources, minimize waste generation and promote practices that align economic efficiency and environmental responsibility. From a theoretical approach, the use of renewable technologies, such as photovoltaic systems and recyclable materials, as well as methods such as waste management, water reuse and passive techniques for energy efficiency is explored. The text also highlights certifications such as LEED, ISO 14001 and Procel Edifica Seal, which boost competitiveness and innovation in the sector. It is concluded that sustainable construction is not only a regulatory obligation, but a strategic opportunity for companies, contributing to environmental preservation and adding economic and social value to buildings.

Keywords: Sustainable Construction. Energy Efficiency. Waste Management. Environmental Certifications. Renewable Technologies.

1 INTRODUCTION

The construction industry plays a crucial role in the economic and social development of nations, representing one of the main drivers of urbanization and modern infrastructure. In recent decades, this sector has experienced accelerated growth, marked by the appreciation of its professionals, expansion of the market and technological evolution. However, such expansion brings with it significant challenges related to environmental and social demands, requiring an increasingly consistent alignment with the principles of sustainability (KIBERT, 2016).

In view of this, civil construction has become a protagonist in discussions about environmental impact, consumption of natural resources and generation of solid waste. Data show that this sector is responsible for about 60% of urban solid waste in Brazil (ABRELPE, 2021) and for a significant consumption of energy and water during the design, construction, and operation phases of buildings. In addition, it is estimated that losses in construction processes still reach 25% in materials, aggravating waste problems (SILVA et al., 2020). Faced with this reality, the adoption of sustainable practices has become an imperative necessity, both from an environmental and economic point of view.

Sustainability in civil construction consists of integrating solutions that reduce environmental impacts and promote efficiency in the use of resources, without compromising the ability of future generations to meet their own needs (WCED, 1987). This approach involves strategies such as reducing carbon emissions, reusing waste, using eco-efficient materials, and incorporating smart technologies. The adoption of sustainable measures, such as the use of solar energy, rainwater reuse systems, and materials with low environmental impact, is capable of reducing the consumption of natural resources and promoting healthier and more efficient buildings (ZENG et al., 2022).

In addition, research shows that, although the adoption of sustainable practices can increase the initial costs of a construction by up to 5%, the economic benefits in the medium and long term outweigh this investment. For example, savings of around 30% in energy and water costs have been achieved in sustainable projects, consolidating the financial viability of this approach (GHISI; FERREIRA, 2020). In addition, such practices give companies a differentiated reputation, reflecting social and environmental responsibility and attracting increasingly conscious consumers.

However, the transition to a more sustainable civil construction industry faces challenges, such as the absence of clear regulations, excessive bureaucracy, and the lack of government incentives. To overcome these obstacles, initiatives such as the Brazilian Committee for Sustainable Construction (CBCS) have sought to promote the dissemination of good practices, the development of national standards, and the training of professionals in the sector (CBCS, 2023). These actions are fundamental for sustainable construction to consolidate itself as a comprehensive reality in Brazil.

Sustainable construction is not only limited to the reduction of environmental impacts during the execution of works, but also encompasses the complete life cycle of buildings. Technologies such as natural lighting systems, use of cross ventilation, efficient thermal insulation, and reuse of materials demonstrate how it is possible to combine user comfort with the preservation of the environment (JACOBSON et al., 2019). In addition, the use of less aggressive materials, such as water-based paints and products free of volatile organic compounds (VOCs), contributes to the health of occupants and the indoor air quality of buildings (LEVI et al., 2021).

Therefore, sustainable construction is an essential model to balance economic progress with environmental preservation, promoting interventions that respect the limits of the planet. This study addresses the main strategies, challenges, and opportunities of sustainability in civil construction, presenting a broad and up-to-date overview of how this sector can contribute to a more balanced and resilient future.

1.1 ENVIRONMENTAL LIABILITY IN CIVIL CONSTRUCTION

Environmental responsibility in construction is a response to the social, economic, and ecological demands that have emerged with the growing global awareness of the need to preserve natural resources for future generations. This concept was largely shaped by the cultural transformations of the 1960s and 1970s, when environmental movements began to gain momentum, pressuring companies and governments to adopt more sustainable practices. In the 1980s, environmental management in companies was no longer seen only as a necessary cost for compliance with legislation and began to be recognized as a competitive strategy, capable of adding value to business (BARBIERI, 2021).

Currently, environmental responsibility is a central pillar of business management, especially in the construction sector, which accounts for about 40% of global greenhouse gas emissions and 30% of natural resource consumption in the world (UNEP, 2020). Companies in the sector have implemented preventive programs, such as waste recycling, reducing energy and water consumption, and using advanced technologies to mitigate environmental impacts. These actions have proven effective not only in reducing damage to the environment, but also in improving corporate image and saving resources in the long term (KIBERT, 2016).

1.1.1 Environmental Management Initiatives and Programs

In recent years, several initiatives have been created to promote environmental management in the civil construction sector. These initiatives aim to guide companies and consumers to adopt sustainable practices. Among the most relevant, the following stand out:

- **Conscious Consumption Campaigns:** Educational campaigns promoted by governmental and non-governmental organizations have played a significant role in raising awareness in society. Examples include the Bag is a Bag campaign (Ministry of the Environment), which encourages the reduction of the use of plastic bags; Earth Hour (WWF), which draws attention to energy savings; and the More is Less program (Akatu Institute), which criticizes predatory consumption.
- **PROCEL Energy Saving Seal:** Developed by the National Program for the Conservation of Electric Energy, the seal identifies products with high energy efficiency, promoting more conscious choices by consumers and stimulating sustainable production. This initiative has a direct impact on the reduction of electricity costs and the advancement of technologies that are less aggressive to the environment (ELETROBRAS, 2022).
- **National Solid Waste Policy (PNRS):** Established by Law No. 12,305/2010, the PNRS is a milestone in solid waste management in Brazil. It establishes shared responsibility between companies, governments, and citizens, encouraging reverse logistics and promoting sustainable production and consumption patterns. In the civil construction sector, the PNRS has fostered the reuse of materials, the reduction of waste, and the adoption of practices that minimize environmental impacts (BRASIL, 2021).
- **Integrated Waste Exchange System (SIBR):** This system facilitates the exchange of information on the reuse of waste, promoting its use as inputs in the production of new materials. This practice not only reduces environmental impacts, but also generates economic value, transforming waste into business opportunities (CNI, 2023).

1.1.2 Sustainable Architecture and Construction

Sustainability in civil construction transcends the choice of materials and methods. It involves a holistic approach that considers the complete life cycle of the building, from the design of the project to its final destination. This includes selecting materials with a low carbon footprint, such as certified wood, recycled concrete, and local materials, which reduce embodied energy in transportation (LEVI et al., 2021). In addition, solutions such as the use of natural lighting, rainwater reuse systems, and technologies for thermal control are examples of how sustainable architecture can balance comfort and efficiency.

Location also plays a crucial role in the sustainability of a project. Urban buildings can benefit from existing infrastructure, such as public transport networks, while rural buildings can use local resources, such as wood and stone, minimizing direct and indirect environmental impacts (GHISI; FERREIRA, 2020). This adaptive approach is key to ensuring that projects are environmentally responsible and economically viable.

1.1.3 Technological Innovations in Civil Construction

Emerging technologies have transformed the construction sector, enabling more efficient and sustainable practices. Technologies such as Building Information Modeling (BIM) allow for more detailed planning and efficient management of resources, reducing waste during the construction process (ZENG et al., 2022). Other innovations include smart materials, such as self-repairing concrete, and building automation systems, which optimize energy and water consumption in buildings.

Environmental responsibility in civil construction is an urgent need, which requires the engagement of all actors involved, from managers and designers to end consumers. The adoption of sustainable practices and the incorporation of innovative technologies not only reduce environmental impacts, but also promote economic efficiency and strengthen the competitiveness of the sector. With clear public policies, adequate incentives, and a growing collective awareness, construction has the potential to lead the transition to a more sustainable future.

1.2 THE MARKET'S DEMAND FOR THE PRESERVATION OF THE ENVIRONMENT

The contemporary market, increasingly attentive to social and environmental demands, has exerted increasing pressure on companies to demonstrate concrete commitments to sustainability. These requirements not only stem from government regulations, but also from more conscious consumers, ethical investors, and international bodies seeking to ensure environmental, social, and governance (ESG) standards. In this context, the implementation of certification systems has become an indispensable tool to meet expectations of quality, health, safety, environmental management, and social responsibility, offering competitive advantages and contributing to the preservation of the environment (BARBIERI, 2021).

1.2.1 Certifications and Sustainable Management Systems

Among the certifications most adopted by organizations is ISO 9001, a standard that establishes standards for quality management systems. This certification promotes the continuous improvement of organizational processes, increasing efficiency, reducing operating costs, and consolidating market confidence in the products and services offered (ABNT, 2023). At the same time, ISO 14001, focused on environmental management, focuses on the implementation of practices that minimize negative environmental impacts, such as the reduction of carbon emissions, the reuse of waste, and the rational use of natural resources (GHISI; FERREIRA, 2020).

In the field of occupational safety and health, the ISO 45001 standard, which replaced OHSAS 18001, presents a global framework to protect workers from occupational accidents and diseases, integrating safe and sustainable practices into business operations (ISO, 2022). These standards not only ensure regulatory compliance, but also reflect the social responsibility of organizations, being a significant differentiator in highly competitive markets.

1.2.2 Procel Edifica Seal and Energy Efficiency

One of the most relevant initiatives in Brazil to promote sustainability in the civil construction sector is the Procel Edifica Seal, part of the National Program for the Conservation of Electric Energy (Procel). This seal certifies buildings that are efficient in the use of energy and natural resources, evaluating criteria such as natural lighting, cross ventilation, efficiency of air conditioning systems and reuse of rainwater. Certification not only encourages the use of clean technologies, but also encourages the adoption of architectural practices that reduce operating costs and increase user comfort (ELETROBRAS, 2022).

Although still underused by the sector, the Procel Edifica Seal is fundamental for the energy transition in Brazil, serving as a reference for more sustainable and efficient buildings. Similar certifications, such as LEED (Leadership in Energy and Environmental Design), widely adopted internationally, demonstrate how civil construction can lead global efforts to mitigate climate change through innovative and environmentally conscious solutions (UNEP, 2020).

1.2.3 International Seals and Sustainability

In the global panorama, certifications such as BREEAM (Building Research Establishment Environmental Assessment Method) and WELL Building Standard evaluate the environmental performance and quality of life provided by buildings. BREEAM, developed in the United Kingdom, measures the sustainability of buildings based on factors such as energy efficiency, waste management and environmental impact. On the other hand, WELL emphasizes the health and well-being of occupants, considering aspects such as air quality, lighting, and thermal comfort (MILLER et al., 2021).

The integration of these criteria into the assessment of buildings reflects a significant advance in the way environmental impacts are managed throughout the life cycle of buildings. It is not just about complying with current legislation, but about demonstrating proactivity in adopting sustainable practices that contribute to reducing the ecological footprint and improving the quality of life of the communities involved.

1.2.4 Sustainability and Competitiveness

The market has increasingly recognized that sustainability is not only a regulatory requirement, but also a strategic opportunity. Certified buildings add value, attract conscious consumers and investors, and reduce operating costs in the long term. Studies show that sustainable buildings can reduce energy consumption by up to 30% and water consumption by up to 50%, in addition to providing savings in maintenance expenses (ZENG et al., 2022). These benefits make environmental certifications a strategic tool for organizations that want to stand out in a competitive and increasingly sustainable landscape.

The market demand for environmentally responsible practices has transformed civil construction into a sector that is increasingly aware of the challenges of sustainability. The adoption of certifications such as ISO 14001, Procel Edifica Seal, LEED and BREEAM demonstrates that it is possible to align economic efficiency, quality and environmental preservation. In addition, the integration of sustainable practices in construction is not only a response to market demands, but also an essential contribution to mitigating environmental impacts and promoting a more balanced future.

2 OBJECTIVES

The objectives presented seek to align civil construction with contemporary sustainability demands, proposing guidelines that prioritize the reduction of environmental impacts, efficiency in the use of natural resources and the promotion of innovative practices in the sector. The objectives structured in a comprehensive and reasoned manner are detailed below:

2.1 PROMOTING RESPONSIBILITY AND PROACTIVITY IN SUSTAINABLE CONSTRUCTION

This objective aims to incorporate sustainability as a core value in the planning, execution and operation stages of buildings. Responsibility and proactivity are related to the adoption of strategies that go beyond compliance with legislation, considering practices that anticipate environmental challenges and meet the expectations of an increasingly conscious society (KIBERT, 2016).

2.2 REDUCE, REUSE AND RECYCLE: COMBATING MATERIAL WASTE

The application of the "3Rs" principle is essential to minimize the environmental impact of civil construction. Strategies such as the reuse of waste at the construction site itself, the use of technologies that reduce the waste of materials, and the encouragement of the recycling of inputs are fundamental practices. Studies indicate that reuse can reduce solid waste in the sector by up to 50%, promoting savings and efficiency (SILVA et al., 2020).

2.3 ADOPT EFFICIENT AND ALTERNATIVE ENERGY SYSTEMS

Energy consumption in the construction sector is responsible for a significant portion of greenhouse gas emissions (UNEP, 2020). The search for energy systems that reduce consumption and waste includes:

- **Technologies based on renewable sources**, such as photovoltaic solar panels and solar water heating systems.
- **Building automation**, which enables intelligent energy management, reducing costs and optimizing use (GHISI; FERREIRA, 2020).

2.4 VERIFY THE FEASIBILITY OF WATER REUSE AND ANTI-WASTE TECHNOLOGIES

Efficient water management is one of the pillars of sustainable construction. This objective emphasizes:

- **Implementation of water reuse systems**, such as the use of rainwater and gray water.
- **Flow control technologies**, such as faucets and showers with aerators, which can reduce consumption by up to **30%** without compromising functionality (JACOBSON et al., 2019).
- Economic and environmental feasibility studies to ensure the implementation of these technologies in an affordable and effective way.

2.5 PRIORITIZE NON-TOXIC MATERIALS WITH LOW ENVIRONMENTAL IMPACT

The choice of materials for construction must take into account both the health of users and the environmental impacts throughout the life cycle of the products. Materials free of volatile organic compounds (VOCs) and those whose production generates lower carbon emissions are priorities. In addition, certifications such as Cradle to Cradle help to identify sustainable and superior quality materials (LEVI et al., 2021).

2.6 VALUING PROJECTS WITH A LONG AND SUSTAINABLE LIFESPAN

The durability of the materials and the flexibility of the design are key factors to ensure the long-term sustainability of buildings. Architectures that prioritize modular, adaptable structures that allow the reuse of components minimize waste and increase the life cycle of buildings (ZENG et al., 2022).

2.7 IMPLEMENT TECHNIQUES FOR MONITORING AND MEASURING ENVIRONMENTAL PERFORMANCE

The implementation of measurement and monitoring systems allows managers and designers to evaluate the environmental performance of buildings in real time. This includes:

- **Sensors for energy and water monitoring**, enabling the identification of inefficiencies.
- Tools based on **Building Information Modeling (BIM),** which optimize the use of resources throughout the project life cycle (MILLER et al., 2021).

2.8 INTEGRATE SOLUTIONS TO MITIGATE GREENHOUSE GASES (GHG)

Poorly planned buildings are significant sources of GHG emissions, both due to the waste generated and the intensive use of energy. This objective reinforces the need to:

- Reduce energy consumption with more efficient systems.
- Reduce the waste of materials that, when discarded, contribute to the emission of methane in landfills (BRASIL, 2021)

2.9 PROMOTE TECHNOLOGIES FOR INDIVIDUALIZATION OF CONSUMPTION

Solutions such as the installation of solar panels in residential complexes are crucial for energy savings, but they can make it impossible to individualize water and energy consumption. Advanced measurement and management technologies are needed to balance energy efficiency with equity in individualized consumption.

2.10 RAISE AWARENESS ABOUT THE IMPACTS OF INADEQUATE PLANNING

Inadequate building planning generates waste of resources, environmental degradation and unnecessary costs. This objective focuses on the need for integrated projects aligned with the best sustainability practices to mitigate these problems, ensuring that waste, water and energy consumption are managed effectively (KIBERT, 2016).

3 SUSTAINABLE MEANS

Sustainable means in civil construction stand out as viable and necessary alternatives to face the environmental and economic challenges of the sector. These methods and technologies make it possible not only to reduce the environmental impact of buildings, but also to improve the efficiency in the use of natural resources, promote energy savings, and offer resilient solutions to climate change. Next, the main sustainable strategies and innovations adopted in civil construction are explored.

3.1 SOLAR ENERGY: PHOTOVOLTAIC PANELS

The use of photovoltaic panels is one of the most widespread and effective technologies in the field of sustainability. By converting solar energy into electricity, the panels significantly reduce dependence on fossil energy sources. Photovoltaic systems offer an average durability of 25 years, with minimal maintenance, limited to periodic cleaning (LEVI et al., 2021). In addition, the savings provided over its useful life compensate for the initial installation cost. Studies show that, in sunny regions, it is possible to recover the investment in about 5 to 8 years, depending on energy consumption (ELETROBRAS, 2022).

3.2 INTERLOCKING BLOCKS

Interlocking blocks, prefabricated concrete, are widely used in urban areas due to their sustainability and functionality. In addition to being non-slip, which makes them ideal for accessibility, they allow water to infiltrate the soil, reducing the risk of flooding and minimizing the effects of urban waterproofing (GHISI; FERREIRA, 2020). These characteristics help mitigate rainwater runoff problems in urban centers, contributing to a more resilient infrastructure.

3.3 PHASE CHANGE MATERIALS (PCMS)

Thermoactive materials, such as phase change materials (PCMs), have stood out as an innovative solution for thermal comfort and energy efficiency. Composed of microencapsulated paraffins, these materials can be incorporated into plasters and coatings, storing and releasing thermal energy during the melting and solidification processes. This technology significantly reduces the need for heating and cooling in buildings, promoting energy savings (JACOBSON et al., 2019).

3.4 GREEN ROOFS

Green roofs, or "green roofs," replace traditional shingles with greenery, creating surfaces that help combat urban heat islands, improve air quality, and promote biodiversity. In addition, these structures act as natural thermal insulators, reducing the need for air conditioning and capturing rainwater for reuse (MILLER et al., 2021). Countries such as Germany and the United States have implemented public policies to encourage the use of green roofs in dense urban areas.

3.5 DURABLE AND RENEWABLE MATERIALS

Highly durable materials, such as improved concrete and treated woods, extend the life of buildings and reduce the demand for new resources. At the same time, the use of materials from renewable sources, such as bamboo and certified wood, ensures that consumption is in balance with environmental regeneration (BARBIERI, 2021). Bamboo, in particular, stands out for its rapid renewal and superior resistance to many traditional woods.

3.6 RECYCLABLE MATERIALS

Recycling materials in construction is a practice that reduces the extraction of new natural resources and the amount of waste sent to landfills. Metals, concrete, glass, and other geological materials have high recycling potential, contributing to a circular economy. The use of demolition waste in new projects is already a reality in many countries, promoting cost reduction and environmental impacts (UNEP, 2020).

3.7 BIOLOGICAL SEWAGE TREATMENT

Biological sewage treatment systems allow the transformation of domestic effluents into treated and safe water, eliminating risks of environmental contamination. This water can be reused in activities such as irrigation, cleaning, or flushing, reducing the demand for drinking water by up to **50%** in buildings (SILVA et al., 2020).

3.8 RAINWATER HARVESTING

Rainwater harvesting and storage systems are simple and effective solutions to reduce the consumption of treated water. The collected water can be used for irrigation, floor cleaning and toilet flushing, with filtration systems that ensure its quality (GHISI; FERREIRA, 2020). The installation of cisterns is recommended in both new and existing constructions.

3.9 WOOD PLASTIC

Plastic wood is a sustainable alternative to traditional wood, made from recycled plastic waste and plant fibers. This material is highly resistant to weathering, does not require frequent painting or maintenance, and has a long durability. Its application in outdoor furniture, decks and other structures has grown, reducing the dependence on wood from forest sources (KIBERT, 2016).

3.10 SUPERADOBE

Superadobe is a material composed of bagged clay earth, widely used in innovative and low-cost constructions. With high structural strength, it is ideal for buildings in areas subject to earthquakes or extreme weather conditions. In addition, its thermal insulation capacity reduces the need for artificial heating or cooling, generating energy savings (ZENG et al., 2022).

3.11 SOLAR WATER HEATING

The use of solar heaters is a proven solution for reducing energy consumption in homes and commercial buildings. Through panels installed on roofs, solar energy is used to heat water, promoting significant savings and reducing carbon emissions associated with the use of electric showers and conventional heaters (LEVI et al., 2021).

The adoption of sustainable means in civil construction is an urgent need to mitigate environmental impacts and promote efficiency in the use of resources. Solutions such as solar energy, renewable materials, water reuse systems and innovative technologies are transforming the sector, aligning economic development and environmental preservation. For these practices to be widely adopted, it is essential to support public policies, financial incentives, and raise awareness among consumers and professionals in the sector.

4 MATERIALS AND METHODS

This study is based on a theoretical approach, focusing on the analysis and systematization of sustainable practices and guidelines applied to the civil construction sector. The methodological proposal aims to understand, through a survey and review of scientific literature, the main trends, strategies and benefits related to sustainability. It also seeks to map over time the practices adopted by companies in the sector in different regions, evaluating how the adoption of sustainable solutions positively impacts society and the environment.

The method adopted prioritizes theoretical and comparative analysis, focusing on identifying the requirements and criteria used for companies in the sector to establish themselves in line with the principles of sustainability. This process includes the assessment of environmental and social impacts, considering the preservation of natural resources such as rivers, tributaries, fauna and flora, and respect for local communities. The study also addresses the analysis of public policies, environmental legislation and international regulations that guide sustainable practices in civil construction.

4.1 GUIDELINES FOR SUSTAINABLE CONSTRUCTION

Based on the theoretical review, the following guidelines are proposed to guide the adoption of sustainable practices in the civil construction sector:

4.1.1 Long-Term Planning

The planning of the works must consider not only the construction period, but the entire life cycle of the building. This approach allows anticipating challenges related to maintenance, operation and disposal, promoting greater economic and environmental efficiency (KIBERT, 2016). Strategies such as Building Information Modeling (BIM) can be employed to optimize resource use and predict impacts over time (ZENG et al., 2022).

4.1.2 Energy Efficiency

Energy efficiency is one of the pillars of sustainable construction. It includes the incorporation of renewable technologies, such as solar panels, solar heating systems, and building automation, as well as the use of insulating materials that reduce the demand for energy in air conditioning (UNEP, 2020). Energy-efficient buildings can reduce greenhouse gas emissions and promote significant financial savings.

4.1.3 Water Use and Reuse

Efficient water management involves technologies for rainwater harvesting, greywater reuse, and flow control systems. These practices make it possible to save water resources and minimize impacts on public supply, in addition to contributing to water resilience in scenarios of scarcity (GHISI; FERREIRA, 2020).

4.1.4 Passive Techniques and Use of Natural Resources

Passive architectural techniques, such as cross ventilation, natural lighting and proper orientation of buildings, use the available natural resources to provide thermal and luminous comfort. This reduces the need for artificial systems, promoting energy savings and greater sustainability (JACOBSON et al., 2019).

4.1.5 Environmentally Friendly Materials and Techniques

The use of sustainable materials, such as recycled concrete, bamboo, certified wood and ecological paints, reduces the carbon footprint of buildings. In addition, choosing construction techniques that generate less waste and use local materials contributes to the reduction of costs and environmental impacts (BARBIERI, 2021).

4.1.6 Solid Waste Management: Reduce, Reuse and Recycle

Efficient solid waste management in the construction sector is essential to minimize environmental impacts. Practices such as the reuse of waste at construction sites and the recycling of materials make it possible to significantly reduce the amount of waste sent to landfills (SILVA et al., 2020).

4.1.7 Comfort and Quality of Indoor Environments

Sustainable projects should prioritize indoor air quality, acoustic control, and adequate lighting. The use of materials free of volatile organic compounds (VOCs) and the creation of thermally comfortable environments promote the well-being and health of users (LEVI et al., 2021).

4.1.8 Soil Permeability

Excessive soil sealing in urban areas is one of the main factors causing flooding. The use of permeable pavements and the preservation of green areas help to manage rainwater, promoting the recharge of aquifers and reducing the negative impacts of urbanization (GHISI; FERREIRA, 2020).

4.1.9 Integration with Sustainable Transport Systems

Connecting new developments with public transport systems, bike lanes, and bicycle infrastructure is essential to reduce dependence on private vehicles, contributing to the reduction of carbon emissions and promoting sustainable mobility (ZENG et al., 2022).

4.2 COMPARATIVE ANALYSIS AND SYSTEMATIZATION OF DATA

The theoretical methodology also covers the comparative analysis of sustainable practices in different regional and business contexts. This analysis will be based on:

- **Case studies**: Evaluation of sustainable construction projects already implemented and their results.

- **Public reports and databases**: Such as the Global Report on Sustainable Construction (UNEP, 2020) and the Panorama of Solid Waste in Brazil (ABRELPE, 2021).
- **Standards and certifications**: Investigation of international guidelines such as ISO 14001, LEED and BREEAM standards.

4.3 EXPECTED RESULTS

The proposed theoretical analysis seeks to:

1. Identify the main sustainable practices adopted by companies in the sector.
2. Highlight the economic, social and environmental benefits of the application of these practices.
3. Propose practical and applicable recommendations to promote sustainability in civil construction.

5 FINAL CONSIDERATIONS

Sustainability is intrinsically linked to innovation and the ability to adapt to constantly changing scenarios. Managers and professionals in the construction sector must commit not only to current demands, but also to anticipating future market needs. Such a posture involves the development of management practices, products and services that incorporate sustainable principles, favor environmental balance and promote the social and economic well-being of impacted communities (KIBERT, 2016).

In the contemporary scenario, companies that stand out for their social and environmental responsibility tend to achieve better financial results and greater appreciation in the market, including in the stock segment. These organizations not only reduce the environmental impacts of their operations, but also become protagonists in social inclusion and sustainable development in the regions where they operate. Studies show that sustainable practices can improve corporate reputation, attract conscious consumers, and increase the competitiveness of companies, both nationally and internationally (BARBIERI, 2021).

Although many of the suggested sustainable practices are already adopted in other sectors, innovation in the civil construction sector lies in its specific application, adapted to the unique characteristics and challenges of the segment. Such practices should not be seen as a rigid set of rules, but as flexible guidelines that can be adjusted to the particularities of each organization. Aspects such as organizational culture, company size, and investment capacity are crucial factors in determining the most appropriate strategies (ZENG et al., 2022).

A key aspect to be highlighted is that most of these practices do not require high financial investments. Simple, effective, and creative solutions can often generate significant improvements in construction processes, work environments, and relationships with stakeholders. Sustainable technologies, such as solar energy systems, rainwater harvesting, waste management, and materials with a low ecological footprint, in addition to contributing to environmental preservation, add value to buildings and provide significant savings over time (GHISI; FERREIRA, 2020).

For example, it is fully feasible to build a sustainable building without exorbitant additional costs. Most sustainable technologies pay for themselves over time through savings generated in resources such as energy, water, and maintenance. In addition, sustainable buildings tend to be more valued in the real estate market, resulting in greater attractiveness in the event of future sale (UNEP, 2020).

Therefore, sustainability in construction should be seen not only as an environmental or regulatory obligation, but as a strategic opportunity to promote efficiency, innovation, and value. Companies that adopt sustainable practices position themselves as agents of change, contributing to a more balanced and resilient future, where progress and preservation go hand in hand.

REFERENCES

Associação Brasileira de Normas Técnicas. (2023). Normas ISO. Rio de Janeiro: ABNT. Retrieved January 15, 2025, from https://www.abnt.org.br

Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais. (2021). Panorama dos resíduos sólidos no Brasil 2021. São Paulo: ABRELPE.

Barbieri, J. C. (2021). Gestão ambiental empresarial: Conceitos, modelos e instrumentos (3rd ed.). São Paulo: Saraiva.

Brasil. (2010). Lei nº 12.305, de 2 de agosto de 2010. Institui a Política Nacional de Resíduos Sólidos. Diário Oficial da União, Brasília, DF, August 3, 2010.

Comitê Brasileiro de Construção Sustentável. (2025). Comitê Brasileiro de Construção Sustentável. São Paulo: CBCS. Retrieved January 15, 2025, from https://www.cbcs.org.br

Confederação Nacional da Indústria. (2025). Sistema integrado de bolsa de resíduos. Brasília: CNI. Retrieved January 15, 2025, from https://www.cni.org.br

Eletrobras. (2022). Relatório anual do Programa Nacional de Conservação de Energia Elétrica (Procel). Rio de Janeiro: Eletrobras. Retrieved January 15, 2025, from https://www.eletrobras.com.br

Ghisi, E., & Ferreira, C. F. (2020). Sistemas de reuso de água e eficiência energética em edificações sustentáveis. Journal of Green Building, 15(4), 12–28.

International Organization for Standardization. (2022). ISO 45001: Occupational health and safety management systems. Geneva: ISO.

Jacobson, R., McIntyre, K., & Nguyen, T. (2019). Sustainable construction practices: Reducing environmental impact. Journal of Environmental Management, 248, 109–120.

Kibert, C. J. (2016). Sustainable construction: Green building design and delivery (4th ed.). Hoboken, NJ: Wiley.

Levi, A., Martins, S., & Costa, R. (2021). Indoor air quality in sustainable buildings. Environmental Research, 200, 111–123.

Miller, G., Smith, R., & Johnson, T. (2021). Sustainable building certifications: Trends and benefits. Building and Environment, 189, 107–120.

Silva, M. A., Oliveira, R. T., & Souza, P. H. (2020). Impactos ambientais e resíduos na construção civil no Brasil. Revista Brasileira de Engenharia, 34(2), 15–30.

United Nations Environment Programme. (2020). 2020 global status report for buildings and construction. Nairobi: UNEP.

World Commission on Environment and Development. (1987). Our common future. Oxford: Oxford University Press.

Zeng, H., Wang, J., & Liu, Y. (2022). Advances in sustainable construction technologies. Renewable and Sustainable Energy Reviews, 165, 112064.