EVALUATION OF IMPROVEMENTS IN THE CONSTRUCTION PRODUCTION PROCESS WITH THE IMPLEMENTATION OF SUSTAINABILITY INDICATORS

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ABSTRACT

Objective: To investigate the adoption of sustainability indicators in civil construction, highlighting advantages and challenges.

Theoretical Framework: In this topic, the main concepts and theories that underlie the research are presented. The environmental legislation pertaining to civil construction and the environmental indicators of the construction site already studied by other authors are highlighted.

Method: The implementation of this Sustainability Program aimed to carry out activities that would help maintain the balance of the construction of the enterprise with the maintenance of natural resources, in addition to bringing employees closer to the socio-environmental theme.

Results and Discussion: The results obtained revealed that it is possible to implement an environmental sustainability program in a construction site and achieve the goals of the indicators.

Research Implications: Investigating the feasibility of other sustainability certifications and standards can broaden the scope of application of sustainable practices in civil construction.

Originality/Value: This study allowed the systematic analysis of the data, showing that sustainable technology was effectively applied in the enterprise. In addition, he highlighted the positive social and environmental impact on employees, reinforcing the idea that it is feasible to build while preserving natural resources for future generations.

Keywords: Civil Construction, Vertical Work, Sustainability, Indicators, ESG.

AVALIAÇÃO DE MELHORIAS NO PROCESSO PRODUTIVO DA CONSTRUÇÃO COM A IMPLANTAÇÃO DE INDICADORES DE SUSTENTABILIDADE

RESUMO

Objetivo: Investigar a adoção de indicadores de sustentabilidade na construção civil, destacando vantagens e desafios.

Referencial Teórico: Neste tópico, são apresentados os principais conceitos e teorias que fundamentam a pesquisa. Destacam-se as legislações ambientais pertinentes à construção civil e os indicadores ambientais de canteiro de obras já estudados por outros autores.

Método: A implantação desse Programa de Sustentabilidade, objetivou a execução de atividades que ajudassem a manter o equilíbrio da construção do empreendimento com a manutenção dos recursos naturais, além de aproximar os colaboradores com a temática socioambiental.

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Evaluation of Improvements in the Construction Production Process with the Implementation of Sustainability Indicators

Resultados e Discussão: Os resultados obtidos revelaram que é possível implantar um programa de sustentabilidade ambiental em um canteiro de obras e alcançar as metas dos indicadores.

Implicações da Pesquisa: Investigar a viabilidade de outras certificações e normas de sustentabilidade pode ampliar o escopo de aplicação das práticas sustentáveis na construção civil.

Originalidade/Valor: Este estudo permitiu a análise sistemática dos dados, evidenciando que a tecnologia sustentável foi aplicada efetivamente no empreendimento. Além disso, ressaltou o impacto socioambiental positivo sobre os colaboradores, reforçando a ideia de que é viável construir enquanto preservamos os recursos naturais para as gerações futuras.

Palavras-chave: Construção Civil, Obra Vertical, Sustentabilidade, Indicadores, ESG.

EVALUACIÓN DE MEJORAS EN EL PROCESO PRODUCTIVO DE LA CONSTRUCCIÓN CON LA IMPLEMENTACIÓN DE INDICADORES DE SOSTENIBILIDAD

RESUMEN

Objetivo: Investigar la adopción de indicadores de sostenibilidad en la construcción civil, destacando ventajas y desafíos.

Marco Teórico: En este tema se presentan los principales conceptos y teorías que subyacen a la investigación. Se destaca la legislación ambiental relativa a la construcción civil y los indicadores ambientales de la obra ya estudiados por otros autores.

Método: La implementación de este Programa de Sostenibilidad tuvo como objetivo realizar actividades que ayudaran a mantener el equilibrio de la construcción de la empresa con el mantenimiento de los recursos naturales, además de acercar a los colaboradores al tema socioambiental.

Resultados y Discusión: Los resultados obtenidos revelaron que es posible implementar un programa de sostenibilidad ambiental en una obra de construcción y alcanzar las metas de los indicadores.

Implicaciones de la investigación: Investigar la viabilidad de otras certificaciones y estándares de sostenibilidad puede ampliar el ámbito de aplicación de las prácticas sostenibles en la construcción civil.

Originalidad/Valor: Este estudio permitió el análisis sistemático de los datos, demostrando que la tecnología sostenible fue efectivamente aplicada en la empresa. Además, destacó el impacto social y ambiental positivo en los empleados, reforzando la idea de que es factible construir preservando los recursos naturales para las generaciones futuras.

Palabras clave: Construcción Civil, Trabajo Vertical, Sostenibilidad, Indicadores, ESG.

1 INTRODUCTION

According to BRUNDTLAND (1987), sustainable development is one that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Civil construction, besides being a front for the work of engineering that allows society
to develop and for there to be economic advance, is a great consumer of natural resources. According to the Brazilian Council for Sustainable Construction (CBCS, 2020), the sector is responsible for consuming 75% of the extracted natural resources. In addition, around 80 tons of works waste are generated annually by companies in the sector. Other factors of concern are the intense consumption of energy in buildings and the emission of greenhouse gases.

In this context, SEVERO and SOUSA (2016) explores how the adoption of assessment tools can contribute to the incorporation of more sustainable practices in the design, construction and operation of buildings. Sustainability, which involves economic and social issues, as well as environmental issues, is a challenge and is slowly gaining ground in the sector.

According to GANTOIS (2018), sustainable development in civil construction represents an opportunity for companies in this sector to seek environmental improvements and increase the economic efficiency of their enterprises. Currently, construction is widely recognized as an industry that significantly impacts the environment, making it crucial to find ways to minimize these effects. In addition, civil construction is identified as one of the main responsible for the intensive extraction of natural resources and the excessive contamination of the environment (GANTOIS, 2018).

The analysis of sustainability indicators in civil construction establishes the fundamental link with the central objectives of this work, which aims to assess the improvements in the productive process of the construction industry by incorporating these indicators. By measuring aspects such as resource consumption, waste management and employee engagement, the indicators not only provide a comprehensive overview of the environmental and social performance of the work, but also offer valuable insights to optimize the production process in a sustainable and responsible manner.

2 THEORETICAL FRAME

CATTELAN (2014) argues that advancing sustainable construction is essential to ensure that current actions do not jeopardize the economic, social and environmental possibilities of future generations. Therefore, the search for sustainable practices is an indispensable component for the continuous evolution and the guarantee of competitiveness in the market.

According to DE FARIAS (2020), from a sustainability perspective, the appropriate use of materials and appropriate waste management can mitigate the generation and impact of waste. Civil construction changes the environment and may have different degrees of
environmental impact according to the practices and materials used. By making more responsible choices, one can reap benefits such as greater comfort, better quality of life and an environment less harmed by toxic substances.

According to GBC Brasil (2020), the construction of sustainable buildings offers several economic advantages, such as reduced operating costs, decreased regulatory risks, property valuation for resale or lease, increased occupancy speed, greater retention and modernization, and less building obsolescence. In the highly competitive scenario of the current Brazilian real estate market, companies seek to provide customers with innovative solutions to the traditional challenges of the sector, offering differentiated services in relation to competition through the implementation of innovations. Therefore, organizations are constantly looking for improvements and upgrades to remain competitive, offering better quality products, compatible prices, unique attributes to customers, and satisfactory returns (PIRES, 2020).

A civil construction work of vertical housing development is subject to various environmental laws that aim to regulate and control the environmental impacts generated by this type of enterprise. Some of the main applicable laws include:

- Resolution CONAMA No. 307/2002: Establishes guidelines, criteria and procedures for the management of construction waste. This resolution defines the obligation to draw up the PGRCC (Civil Construction Waste Management Plan) for works in this segment;
- Law 12.305/2010 - National Policy on Solid Waste (PNRS): Regulates the disposal and management of solid waste throughout the country, encouraging the reduction, reuse, recycling and proper treatment of waste generated in Works;
- Resolution CONAMA nº 001/1986: Provides for environmental licensing, which is the process by which the environmental impact of a work is assessed and the appropriate authorizations for its operation are granted.

According to Resolution No. 307/2002 of the National Council of the Environment (CONAMA), waste management is guided in a logistical system that aims to reduce, reuse or recycle waste. This is achieved through the development of programs covering responsibilities, habits, procedures and resources, with the aim of promoting and coordinating necessary actions at all stages envisaged in the content and plan.

Construction is one of the most solid waste producing activities in the world, about 35% to 40% of all waste generated by humanity (BELTRAME, 2013). This waste may come from demolitions, excavations, leftovers, among other materials. If not managed properly, these materials can cause significant environmental problems, such as soil and water contamination, obstruction of drainage systems, and worsening air pollution.
Ordinance 280 of the Brazilian Ministry of the Environment was created with the objective of regulating the Arts. 56 and 76 of Decree No. 7.404, of December 23, 2010, and Art. 8 of Decree No. 10.388, of June 5, 2020. In addition, she instituted the national Waste Transport Manifesto (MTR) as a management tool and declaratory document for the implementation and operationalization of the Waste Management Plan.

This regulation is of utmost importance for the advance in environmental management and in the control of solid waste in Brazil. By establishing the national MTR and strengthening the National Inventory of Solid Waste, the Ministry of the Environment seeks to promote a more efficient and sustainable management of waste, contributing to the protection of the environment and the promotion of the circular economy in the country. Implementation and compliance with the provisions of the Ordinance are essential for the fulfillment of environmental responsibilities by companies and organizations involved in the generation, transport and disposal of solid waste, and for ensuring the preservation of natural resources and the quality of life of present and future generations.

In a study conducted by KATZ and BAUM (2011), researchers from Israel, a model was developed based on a field survey that monitored 10 construction sites of residential buildings under construction. From the collected data and the elaborate model, the authors came to the conclusion that approximately two thirds of the total amount of waste is generated during the last third of the construction time.

The model proposed by KATZ and BAUM (2011) estimates that the average amount of waste generated during the construction of residential buildings is approximately 0.20 m³/m². Such estimation can serve as a reference to assess the expected amount of waste in different construction projects and encourage the adoption of more efficient and sustainable waste management practices.

CARVALHO E RORIZ (2020) performed a study in civil construction works in Goiânia in which the results obtained demonstrated an estimated consumption between 0.20 and 0.25 m³/m² of built area.

MARQUES (2017) presented a paper where there was a research of energy consumption in civil construction works that varied considerably, presenting values between 0.27 kWh/m² and 9.93 kWh/m². This significant variation can be attributed to the different construction and finishing characteristics of each work. In this study, the work that most closely resembles the work under study obtained a built consumption of 7.11 kWh/m².
3 METHODOLOGY

The implementation of this Sustainability Program, aimed to implement activities that would help maintain the balance of the construction of the enterprise with the maintenance of natural resources, besides bringing collaborators with the socio-environmental theme. The Sustainability Program implemented started from five premises to achieve sustainable development. They are: solid waste, water resources, energy resources, socio-environmental interaction, and human resources.

Within each premise, the main factors that allow the identification of the positive impacts arising from negative aspects inherent to civil construction were evaluated. As an example we quote:

- Water resources: management of water consumption, avoiding waste and promoting pre-treatment at consumption points where this possibility exists;
- Energy resources: managing energy consumption, avoiding waste and promoting sustainable practices in the consumption of energy resources;
- Socio-environmental interaction: promotion of visual and ‘brand’ identification within the work with the sustainable practices developed;
- Human resources: promoting employee training, returning to social benefits and valuing joint actions in favor of sustainability in the work.
- Solid waste: control of environmentally appropriate final destination, through the emission and monitoring of MTRs, implementation of selective collection, identification of bays, segregation of waste at generation points and control of the volume of waste;

The implementation phase of the sustainability program in the work took place in such a way that recognition visits of the work were carried out, thus it was possible to activate partners for the environmentally adequate removal of recyclable waste and the definition of weekly visits to align sustainability indicators and implement sustainability signage.

In addition, employees were instructed on the start of the sustainability program and on what the next steps would be, aiming to raise awareness and return the results of the program to the employees, with communication and transparency.

The project team was present in the alignment activities carried out during the program's development, such as the initial meeting, presentation to the employees about the sustainability program (Figure 1), interactions to define the best possibilities for visual communication.
regarding the sustainability program and definition of the phases that the program will go through.

At this moment, a presentation was made to the project’s administrative team on how the indicators would be implemented (Figure 2), how the weekly visits would be carried out, how the score would be applied, how the points of improvement would be reported and how the project administration could be involved in order to achieve the success of the implementation of the sustainability program.

**Figure 1**

*Alignment meeting with the work collaborators*

Source: The Author Himself, 2023.

**Figure 2**

*Alignment meeting with the project management team*

Source: The Author Himself, 2023.

In the alignment meetings with the employees, usually in the DDS, the weekly evolution and points of improvement were presented. There was also training for the front line, allowing for the optimization of the segregation of the waste, the management of water and energy resources and other activities.
In addition, a recognition of the status of the work was carried out to verify the initial situation (Figure 3) and weekly visits to monitor the implementation of the indicators. During the weekly visits, the employees closely monitored the guidelines and the doubts were resolved at the time so that the actions could be carried out and the proposed indicators could be achieved.

**Figure 3**

*Recognition of the work with collaborators.*

The weekly technical visits represented the main instrument of monitoring and communication between the work's team and the author. Thus, these visits took place weekly during the period of execution of the work. During the weekly technical visits, an evaluation form was completed on the general conditions of the work, with a score of 50% to 100%, according to Table 1 for the following criteria evaluated.

**Table 1**

*Levels of compliance with the criteria analyzed.*

<table>
<thead>
<tr>
<th>Value</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;59%</td>
<td>Bad</td>
</tr>
<tr>
<td>60% to 70%</td>
<td>Regular</td>
</tr>
<tr>
<td>71% to 80%</td>
<td>Good</td>
</tr>
<tr>
<td>81% to 90%</td>
<td>Great</td>
</tr>
<tr>
<td>&gt;90%</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Source: The Author Himself, 2023.

The evaluation criteria provided a scenario of the situation of the work in different aspects of the sustainability program and allowed for monitoring progress, setbacks and possibilities for improvement on all the work fronts. In addition, during the weekly visits the
questions and suggestions of the employees were received to reflect on training actions, deployment and guidelines for better adaptation to sustainable practices coming from the Sustainability Program.

The Sustainability Program implemented in the study work was managed in such a way that the actions developed could be identified in data that supported the full monitoring of the program. This data reflected the control of the partners to be activated for the removal of waste; the control of water and energy consumption; the control of the waste taken out, by classification and destination; the information of the weekly visits and scores; the information of the trainings and the control of the indicators of the program.

This information has been summarized and presented in the periodic monitoring reports. This management was essential for the development of indicators and to generate reporting of results.

The final indicator for water consumption was defined as the total consumption during the construction period, by the total constructed. The target set for this indicator was according to the study by CARVALHO and RORIZ (2020), that is, the value of 0.21 m³ of water per m² built. Throughout the work, the monthly indicator was compared with the target, assessing whether it was above or below and how much, noting if any discrepancies could refer to a specific phase of construction.

The final indicator for electric energy consumption was defined as the total consumption during the construction period, by the total constructed. The target set for this indicator was according to the study by MARQUES (2017), thus adopting 7.11 kWh consumed per m² of built work. Throughout the work, the monthly indicator was compared with the target, assessing whether it was above or below and how much, noting if any discrepancies could refer to a specific phase of construction.

The final indicator for waste generation was defined as the total generation, during the construction period, by the total built. As a goal, 0.20 m³ of waste generated per m² of built work was used, following the study by KATZ and BAUM (2011). Throughout the work, the monthly indicator was compared with the target, assessing whether it was above or below and how much, noting if any discrepancies could refer to a specific phase of construction.

The final indicator for recycling or reuse of waste was measured monthly, informing the destination of the waste and calculating the percentage that was not destined for the sanitary landfill, that is, followed for reuse or recycling. The target set was that at least 50% of the waste generated would be recycled or reused, whether in the construction works or destined for recovery or recycling.
The final indicator for the MTR conference was defined as the requirement that at least 80% of the waste destined for the works be accompanied by the MTR.

4 RESULTS AND DISCUSSIONS

The figure below shows how the work performed on sustainability criteria during the 30 months monitored and represents the average of each criterion in a sum of 4 visits per month during 30 months.

Figure 4
Performance of the work by criterion assessed over 30 months

Source: The Author Himself, 2023.

Legend of the Criteria in Figure 4: 1) Cleaning and general organization; 2) Waste volume at generation points; 3) Quality of segregation at generation points; 4) Quality of waste segregation in bays; 5) Signage of the work in relation to the sustainability program; 6) Use and waste of water and energy resources; 7) Participation of employees in the sustainability program; 8) Effluent Treatment; 9) Pollution Prevention; 10) Waste Management in the Administration and Cafeteria
Figure 5

*Meeting Criteria (average) per month over 30 months*

Source: The Author Himself, 2023.

Figure 6

*Evaluation Criteria Summarized over 30 months*

Source: The Author Himself, 2023.

Figure 7

*Water consumption over 30 months*

Source: The Author Himself, 2023.
During the 30 months monitored, the work under study generated 1292.32m³ of waste, equivalent to 1374.65 tons of waste. Of these, 855.00 m³ was Class A waste; and 437.32 m³ was Class B waste. The waste generation factor was 0.07 m³ of waste per m² built.
During the period monitored, 30 months, the work achieved the objective of remaining with a water consumption below the reference value by at least 10%. In general, the water consumption factor for each m² built was 0.16 m³/m² built, which is below the reference value of 0.17 m³/m².

During the period monitored, 30 months, the work failed to reach the reference value for energy consumption in kWh per m² built, defined as 7.11 kWh/m². The constructed value of 7.63 kWh/m² is above the reference value. However, the technologies undertaken in the execution of this enterprise were a milestone in the company's constructive method, which now has a reference value for this criterion for new enterprises.

5 CONCLUSION

The implementation of sustainability indicators in a vertical work in Goiânia-GO represented a challenging challenge, since it required adaptation to the demands and objectives of sustainable development. These challenges have become a source of motivation for the entire team, which, in close collaboration with senior management, has worked tirelessly to meet the established sustainability criteria.

After a 30-month monitoring period of the implementation of these indicators, we have achieved remarkable achievements. We have established an Environmental Policy and Integrated Management Policy, we have successfully completed two certification processes (system B and ISO 14.001), which represents a significant milestone for vertical enterprises in the region.

It is important to point out that almost all the proposed indicators have been achieved, with the exception of energy consumption. However, this discrepancy may be justified by the
technology employed in the enterprise, which may not be fully reflected in the energy consumption indicators.

Ultimately, this work allowed the systematic analysis of the data, showing that sustainable technology was effectively applied in the enterprise. In addition, he stressed the positive socio-environmental impact on employees, reinforcing the idea that it is feasible to build while preserving natural resources for future generations.

For future research, we suggest exploring further the energy consumption indicator, looking for ways to optimize energy use in similar ventures. In addition, investigating the feasibility of other certifications and sustainability standards can broaden the scope of application of sustainable practices in construction. Such studies can contribute to a more conscious and responsible development in the construction sector.

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