CHAPTER
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Contribution of civil construction in the emission of gases involved with greenhouse effect

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ABSTRACT
Civil construction is one of the most important industries in the world, responsible for the creation of housing, infrastructure, and commercial buildings. However, this industry is also a major source of greenhouse gas (GHG) emissions, including carbon dioxide (CO2), which contributes to climate change. In addition, construction is also a source of other air pollutants that contribute to the degradation of the ozone layer. In this context, research conducted with the impacts of civil construction that contribute to the emission of greenhouse gases and degradation of the ozone layer is presented, as well as the development of actions to minimize GHG production by 2030, being a challenge that requires commitment and changes in the culture of the construction industry. Construction has the responsibility and opportunity to lead this change to promote a more sustainable and just future for all. In addition, solutions are presented to minimize the emission of polluting gases in civil construction, highlighting the importance of energy efficiency, the use of alternative materials, and the adoption of efficient and innovative practices in construction and operation, without compromising the quality and structural performance of buildings.

Keywords: Construction; Energy efficiency; Pollutant gases; Environmental Impacts; Green technologies; Sustainability.

1 INTRODUCTION

The National Confederation of Industry (CNI), 2017, civil construction – also called the construction sector or construction industry – comprises a complex and heterogeneous production chain composed of the segments of extraction, supplies, trade, and services and construction. The core of civil construction is composed of builders, developers and service providers, and various segments of the building materials industry and commerce. In addition to this core, industrial complexes, which supply the sector with inputs necessary for production, also form the civil construction chain.

The construction industry is a very important sector for the economy of any country, as it is responsible for the development of the physical infrastructure of residential buildings, shopping

centers, industrial plants, roads, bridges, ports, and other engineering projects. In addition, according to the Annual Social Information Report (RAIS), 2020, in Brazil, the construction industry generates a large volume of jobs, which makes it vital to the Brazilian economy.

Confirming its contribution to the massive generation of jobs, according to the Institute of Geography and Statistics (IBGE), 2020, through the last recorded publication of the annual survey of the construction industry (PAIC), says that the construction sector employed 2 million workers in 2020, even though it was a year that the world was going through a pandemic.

The Brazilian Institute of Geography and Statistics (IBGE), 2020, reports that in the first year of the pandemic of the new Coronavirus, the construction sector mobilized a total of 131,800 active companies that employed 2 million people, which R$ 58.7 billion in salaries, withdrawals, and other remuneration were paid.

Regarding the generation of direct jobs, the construction industry has an important contribution to the generation of indirect jobs, such as suppliers of construction materials, transportation services, and other related activities. According to the Brazilian Chamber of the Construction Industry (CBIC), 2020, for every R$ 1 million of investment, civil construction creates 7.64 direct jobs and 11.4 indirect jobs; which generate R$ 492 thousand and R$ 772 thousand reais on GDP, respectively. Therefore, most of what is invested in construction in Brazil returns as GDP, employment, tax, and income.

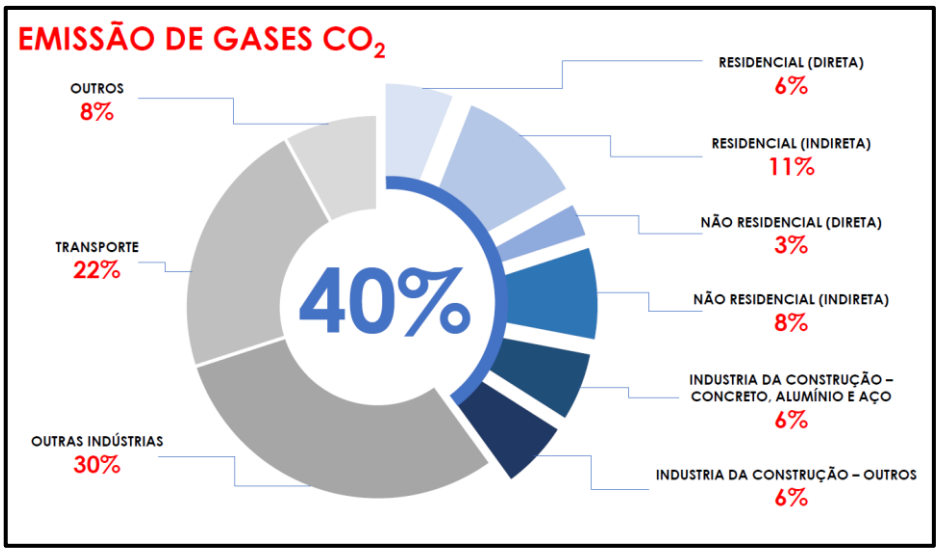
Complementing the information, construction also has a significant impact on the economy as a whole. According to the Brazilian Institute of Geography and Statistics (IBGE), 2022, the results of the Gross Domestic Product (GDP) of 2022, presented a growth of 2.9%. This increase was only achieved due to the good performance of the GDP of Civil Construction, which increased by 6.9% in the same period.

In addition, civil construction has a multiplier impact on the economy, that is, each real investment in civil construction generates a positive impact on the economy much greater than the amount invested itself. According to the material prepared by the National Union of the Heavy Construction Industry (SINICON), 2021, the multiplier of the construction sector is 1.44 to GDP. This means that each real investment in civil construction generates a positive impact of R$1.44 on the economy.

Therefore, the construction industry is one of the most important in the Brazilian industrial scenario, not only for the large number of financial resources it moves but also for the generation of jobs. On the other hand, to occupy these prominent positions, it is responsible for the high consumption of energy and natural resources, contributing to a large share of emission of polluting gases, especially carbon dioxide (CO2), corroborating the degradation of the ozone layer, as well as for intensification of the greenhouse effect. According to the UN Report, 2019, and data from the United Nations

Environment Programme (UNEP), 2019, construction is responsible for about 40% of CO2 emissions in the atmosphere and for about 34% of total energy consumption in the world, for more details, the following is an adapted UN graph on the share of each segment of civil construction in CO2 emissions (Figure 1).

Figure 1 - Graph with the main segments of civil construction that corroborate the emission of carbon dioxide into the atmosphere and its total share.



Source: Adapted from the United Nations Environment Programme (UNEP), 2019

According to the United Nations Environment Programme (UNEP), 2019, one of the main reasons why construction is so polluting is the fact that most building materials are produced from finite and non-renewable natural resources. For example, concrete production is highly carbon-intensive, since it is necessary to heat large amounts of limestone and clay in kilns to very high temperatures.

The main materials used in most civil constructions are sand, cement, brick, tiles, glass, wood, steel, aluminum, and wood. According to the IDD Institute - Institut Wallon - VITO, 2001, these are the materials that contribute the most to gas emissions in the atmosphere, from their extraction to the manufacture and transport of the final product.

In addition, the production of cement, one of the main components of concrete and widely used, according to the Global Cement and Concrete Association (GCCA), 2020, cement manufacturing is responsible for between 5% and 8% of global GHG emissions. According to John (2017), in addition to cement, materials such as ceramics, steel, and glass are responsible for important CO2 emissions, for better visualization presented below, the ratio of carbon dioxide emission emitted by each ton of the main materials produced (Table 1).

Table 1 - Table with the presentation of the main materials produced and used in the construction civil and its relationship between production x CO2 emission in tonne.

MATERIAL	DISTRIBUTION OF MATERIALS (In tonnes)	CO2 GAS EMISSION (Issued for distribution in tonnes)
CLINQUER (Cement product)	1	0,8 - 1
CEMENT	1	0,6
STEEL	1	1,2 – 1,8
CAL	1	0,4
GLASS	1	0,8
BRICK	1	0,16 – 0,5

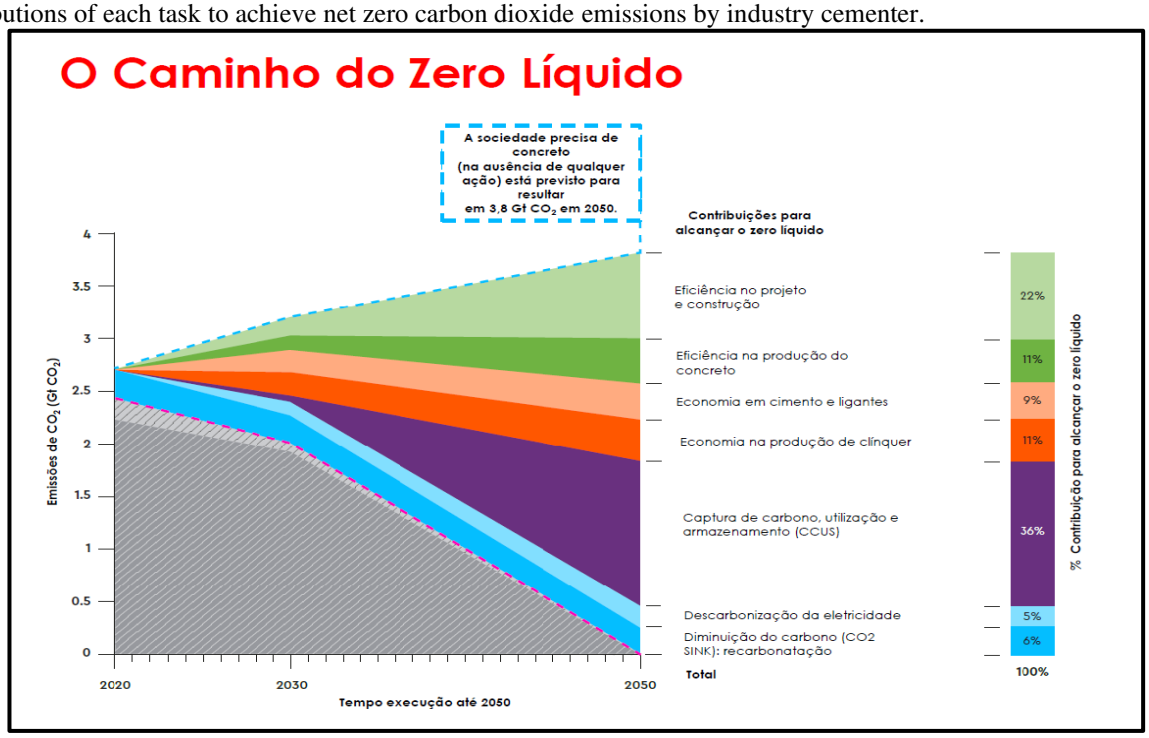
Source: Own authorship

Another factor contributing to CO2 emissions in construction is the waste of building materials. For Silva and Souza (2015), the construction sector is the main responsible for economic expansion and one of the main environmental villains. Complementing, Brasileiro, and Matos (2015), informs that the consumption of raw materials stands out, involves processes with high energy consumption, generates pollution in almost all its processes and even in the phase of use of buildings, as in the phases of repair and maintenance that also use a large volume of resources and cause numerous environmental impacts.

Given the large share of contribution to GHG emissions. As presented by the United Nations Union – Brazil (2015), presents the sustainability program, with the proposed goal for civil construction to halve the emission of greenhouse gases by 2030, including carbon dioxide. This proposal was established by the Paris Agreement in 2015, which was signed by 196 member countries of the United Nations (UN) and aims to limit global warming to less than 2°C above pre-industrial levels, therefore, it is an important sector to achieve this goal set by the Paris Agreement.

However, there is no specific law that requires the reduction of carbon dioxide emissions in construction, but rather a global commitment made by the signatory countries of the Paris Agreement in addition to specific associations such as the Global Cement and Concrete Association (GCCA), 2020, which has created a roadmap that establishes a path for cement industries to reduce CO2 emissions by 25% by 2030 and zero emissions by 2050, helping to limit global warming to 1.5ºC, according to the adapted chart below the GCCA, 2020, which shows the "tasks" to reach zero carbon emissions to which each will be implemented according to factors (Figure 2).

Figure 2- Graphic representation of the script proposed by the Global Cement and Concrete Association (GCCA) with the contributions of each task to achieve net zero carbon dioxide emissions by industry cementer.



Source: Adapted of Global Cement and Concrete Association (GCCA), 2020)

Several lines of research developed shows that the construction industry can adopt measures to reduce its share of contribution to the emission of polluting gases. For the Brazilian Institute of Cost Engineering (IBEC) (2019), sustainability should be an item evaluated from the beginning of the work. Thinking about efficient solutions during construction until the end of the building's useful life. Building sustainably is prioritizing development without compromising natural resources. Given the above, below are some solutions proposed by IBEC to achieve sustainability in civil construction.

2 EMISSIONS OF POLLUTING GASES BY THE CONSTRUCTION INDUSTRY

2.1 USE OF RENEWABLE ENERGY SOURCES

According to IBEC (2019), one of the most effective solutions to reduce CO2 emissions in civil construction is the use of renewable energy sources, such as solar energy, and geothermal wind, among others. These energy sources are renewable, inexhaustible, and non-polluting, which makes them ideal for construction. It is worth mentioning that renewable sources in addition to reducing the emission of greenhouse gases and contributing to the preservation of the environment, their use can also generate financial savings in the long term.

2.2 USE OF SUSTAINABLE MATERIALS

For IBEC (2019), another important measure to reduce CO2 emissions in civil construction is the use of sustainable materials. Materials such as ecologically certified wood, raw earth bricks,

ecological paints, thermal insulators made from recycled materials, and tiles from recycled products are more sustainable alternatives to conventional materials, which require a large amount of energy for manufacturing or processing and emit CO2 into the atmosphere.

For the National Confederation of Industry (CNI) (2017), the adoption of sustainable materials in civil construction can bring benefits such as reducing greenhouse gas emissions, saving natural resources, and improving the quality of life of building users. In addition, practices and initiatives aimed at sustainability in civil construction have become increasingly valued by the market and conscious consumers.

2.3 EFFICIENT WASTE MANAGEMENT

According to IBC (2019), waste in construction is a major problem. It can be caused by improper use of materials, losses during transportation, improper storage, and problems on the construction site, for example. Efficient waste management is another important measure to reduce CO2 emissions in construction. Waste generated during construction should be properly separated and recycled or repurposed whenever possible to reduce the amount of waste that is disposed of in landfills.

In Brazil, there is the Resolution of the National Council of the Environment (CONAMA) No. 307/2002 which establishes the guidelines, criteria, and procedures for the management of civil construction waste through the creation of waste classes and their proper destination. This waste disposal must follow the hierarchy established in the resolution, prioritizing the reduction, reuse, and recycling, before the final disposal in landfills or boot-out areas. In addition, the generation, transportation, and disposal of waste must be recorded and must be filed by the company generating the waste and by the company that collected and transported it to the final destination. In summary, according to Tozzi (2006), waste management in civil construction is an important issue that must be properly managed, according to the guidelines and criteria established by the CONAMA Resolution mentioned above. Compliance with these guidelines is fundamental for the preservation of the environment and the promotion of sustainability in civil construction.

2.4 ENERGY EFFICIENCY

For IBEC (2019), improving the energy efficiency of buildings is one of the most important solutions for reducing CO2 emissions in civil construction. For this, it is necessary to use more efficient lighting and air conditioning systems and more sustainable water heating systems, in addition to improving the thermal insulation and sealing of buildings.

An interesting proposal is the adoption of special glass, in addition to being from products with low GHG emission recycled glass, the use of special glass, such as low emissivity glass, can reduce

energy consumption for air conditioning of buildings, making them more efficient and sustainable. According to the Brazilian Association of Distributors and Processors of Flat Glass (ABRAVIDRO), the special types also have functionalities that collaborate with sustainability, such as solar control glass contributes to the energy efficiency of buildings, providing greater thermal comfort and reducing air conditioning consumption; the insulates (also called doubles) maintain the internal temperature with lower energy expenditure, either to cool or heat and still offer acoustic comfort; self-cleaning reduces the consumption of cleaning supplies; The photovoltaic panels, also composed of glass, allow the self-generation of electrical energy.

To encourage the adoption of these solutions and based on the United Nations Environment Program (UNEP), targets were created to achieve them, mainly in the halving of the emission of polluting gases by civil construction. The main initiatives developed to follow are as follows.

2.4.1 International commitment

According to the 2015 Paris Agreement, halving greenhouse gas emissions by 2030 is an ambitious goal that requires an international commitment from the construction industry. For this, governments, companies, and organizations must work with four hands, to implement measures that promote sustainability in construction.

2.4.2 LEED Certification

According to the Green Building Council Brazil, one of the most important initiatives to promote sustainability in civil construction is the LEED (Leadership in Energy and Environmental Design) certification. This certification is one of the most recognized and used in the world for sustainable buildings. Developed by the U.S. Green Building Council (USGBC), LEED seeks to encourage and recognize buildings with superior environmental performance and that provide a healthy and productive environment for their users.

Also, according to the Green Building Council Brazil, the LEED certification system is based on specific criteria that evaluate aspects such as efficient use of natural resources, reduction of environmental impact, indoor air quality, innovation, and technology, among others. Obtaining LEED certification can be of great value to construction companies and building owners since it can bring benefits such as increased market-added value, reduced operating costs, and notoriety of the property in the construction segment.

3 CLEAN TECHNOLOGIES

According to Barbieri (1997), the term innovation can represent different meanings according to the approach used. For the marketing area, innovation can be any change perceived by the consumer,

even if no physical change occurs in the product. This concept can be understood as subjective and based on mental representations and interpretations that each customer makes of the product.

For Pereira et al. (1997), Clean technologies are nothing more than the adoption of any measure of change or transformation of methods used to reduce, or rather, eliminate, already at the source, the production of any type of pollution - noise, atmospheric, hyperspherical, etc., evidently, that helps in some way to save raw material and energy, in short, all the resources, natural or not.

Still Pereira et al. (1997), technology is another important initiative to reduce the emission of polluting gases in civil construction is the use of clean technologies, such as modular construction and 3D printing. This technology is heavily invested in some developed countries, its adoption reduces the amount of waste generated during construction and decreases the construction time. 3D printing can be used to produce prefabricated parts quickly and efficiently, reducing the need to transport materials. Raising the concept of industrialization of civil construction and promotion, with lower chances of rework.

4 ENVIRONMENTAL EDUCATIONS

Environmental education is a continuous and permanent process necessary for the formation of values, attitudes, and practices aimed at the preservation and conservation of the environment. This form of education is fundamental for the construction of a more conscious and responsible society about the use of natural resources and the preservation of the planet.

Given this, according to the National Confederation of Industry (CNI), (2017), the moment that Brazil and the world are going through demonstrates the importance of committing to change. The construction industry has a high power to contribute to the reduction of environmental impacts and the construction of more prosperous and healthy cities. It is necessary to choose sides, define projects, fight for objectives, and participate so that communication with public management is clear, transparent, and effective and so that information reaches companies and society, consolidating the course of change that the sector is committed and prepared to follow.

And yet, the National Confederation of Industry (CNI), (2017), cities are changing and, very quickly, the construction sector can contribute positively to this change, strengthening the importance of planning. In Brazil, planning has been neglected in the scope of public management and it is necessary to rescue the effectiveness of planning, especially considering the city of the future that aims to reduce carbon emissions, mobility, intensive use of information technology (IT), and social networks, among other technologies and solutions aimed at sustainability.

In addition to the technical measures to achieve a halving of GHG emissions from civil construction, environmental education is fundamental to promoting sustainability in civil construction.

Construction professionals should be made aware of the importance of reducing the emission of polluting gases and the sustainable practices that can be adopted during construction.

Given all that has been covered in this chapter, where it presents, that in fact, the construction industry is responsible for a large share of emission of polluting gases, especially carbon dioxide (CO2), which is extremely harmful to the environment. It also presents the existence of several solutions that can be adopted to reduce CO2 emissions, as mentioned earlier: the use of renewable energy sources, sustainable materials, efficient waste management, energy efficiency, LEED certification, clean technologies, and environmental education, among others.

Therefore, to achieve the goal of halving greenhouse gas emissions by 2030, a worldwide commitment by the construction industry to the implementation of sustainable measures in all phases of construction is necessary. Therefore, it is necessary that all those involved, from governments and companies to professionals in the area, unite to promote sustainability in civil construction and reduce their share of contribution to the emission of polluting gases.

The adoption of sustainable practices in civil construction is not only an environmental responsibility but also an opportunity for innovation and development for the sector. The use of clean technologies, sustainable materials, and energy efficiency can not only reduce the emission of polluting gases but also bring economic and social benefits, such as cost reduction, compliance with construction systems concerning the minimum required performance that brings a positive consequence the guarantee of comfort to the user and greater durability of the buildings.

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