

Contribution of Patent Information for Obtaining Mortars with Construction and Demolition Waste (CDW) as Recycled Aggregate

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Abstract: Civil construction is one of the most important sectors for economic and social development, alternatively, it is a generator of waste that is commonly discarded in an irregular manner causing negative environmental impacts. Seeking knowledge in databases for innovation has become a common practice in most organizations in the development of new products, due to the evolution of information technology. Patent data shows changes in the structure and development of a country's creative activities in technologies, industry, and companies. Analyzing the competitiveness between inventors and companies is feasible as patents contain descriptions of inventions and their functionalities. This study aims to collect patent information on mortars using construction and demolition waste (CDW) as an alternative raw material. We performed the research in an exploratory way with the purpose of defining more viable technological routes, determining the types of materials to be used, and the minimum and maximum percentages of substitution of the natural aggregate for the recycled aggregate. We used the patent databases Google Patents, European Patent Office (EPO) through Epacenet, and World Intellectual Property Organization (WIPO) available on Patentscope. As a result, 70 patent application records were identified according to the search descriptors, with Brazil as the country with the highest number of registrations. A survey of the number of patents deposited, published, office, and/or country was performed following the International Patent Classification. The results have the potential to contribute to the design of improvement strategies when using construction and demolition residues in mortars.

Keywords: Construction and demolition waste, Mortars, Patent information, Sustainability, Technological innovation, Data mining, Data analysis.

Adherence to the BJEDIS' scope: The research addresses the use of patents as a source for performing data analysis. Patents can contain information useful for technological prospecting on a given topic making it an important source of research to define market strategies. Therefore, patents can contribute to the process of obtaining knowledge being used as a tool to assist researchers and professionals.

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1. INTRODUCTION

Civil construction is the industry that consumes the most natural resources and the one that generates the most waste, in addition to the generation of dust and noise pollution at construction sites. Government agencies and professionals in the field ignored the topic of civil construction for a long time, although civil construction waste is present in all cities and is equivalent to that of urban waste. It is relevant to note that this field was only included as an industry with sustainable problems from the 1990s onwards (1).

Construction and demolition wastes are often irregularly disposed of and can cause problems such as contamination of soil, surface, and groundwater, shelter from pathogens; in addition to negatively influencing the populations' quality of life (2).

Innovation is a term with several different concepts, the term is derived from the Latin *innovare*, which means to do something new. Innovation is a process, it is not enough to have good ideas, but necessary to make these ideas have a practical use (3). Innovation can be the production of a new product or the improvement of an existing product, or processes and methods adopted by companies or organizations (4).

Companies must innovate while thinking about the three dimensions of sustainability, which characterize sustainable innovation: social, environmental, and economic. The social dimension is concerned with social impacts such as unemployment, social exclusion, poverty, diversity, etc.; the environmental dimension is concerned with environmental impacts such as the use of natural resources and the emission of pollutants; and the economic dimension is concerned with economic efficiencies, such as creating profits for companies (5).

One of the oldest ways to protect inventions is patents, since the 17th century, they contain records of technological innovations and can be public documents as a source of knowledge of technical information indicating the level of innovation of a country or region according to the quantity of patent registrations (6).

Therefore, this work aims to conduct a survey of information, contained in international patent databases, on the production of construction mortars using construction and demolition waste (CDW) as an alternative raw material, with the purpose to contribute to the sustainability of the civil construction sector.

1.1. Bibliographic Review

The following describes concepts related to sustainability, construction and demolition waste (CDW), and patent information.

1.1.1. Sustainability in Civil Construction

Society uses the environment to extract the necessary raw material, however, this extraction causes negative environmental impacts such as the generation of residues and pollutants that are harmful to both the environment and the population (7).

The extraction of raw materials can lead to the depletion of finite natural resources. Civil construction is the sector that consumes the rawest materials, besides, their waste is often inappropriately disposed of (8). According to Lima and Lima (9), the construction of new homes and buildings and demolition work generates large quantities of construction and demolition waste (CDW). However, in most of these works, their transportation and disposal are inadequate. Disposals are done in inappropriate places such as landfills, hillsides, and public roads, causing discomfort for the population.

These impacts are directly related to the projects, considering the lack of definitions and/or satisfactory details, inaccuracy in the descriptive memorials, inconsistency of the materials, low qualification of the workforce, poor handling, inadequate transport/stock at the construction site, deficiency of appropriate mechanisms to have control of the execution of the work, choice of technique to be used, and without forgetting the precariousness of recycling processes at the construction site (9).

Therefore, to minimize these impacts, the concern with recycling has increased over the years. one of these ways is the reuse of construction and demolition waste, reducing the extraction of raw materials and the irregular disposal of this waste (10).

1.1.2. Construction and Demolition Waste (CDW)

Resolution No. 307/2002 of the National Environment Council (NEC) was created due to the high concern over the large generation of waste. This resolution establishes criteria and procedures for the management of construction and demolition waste (CDW) (11). According to Article 3, the item I of this resolution, construction and demolition waste (CDW) is classified as ceramic components, air grease, concrete, and demolition of precast pieces, and are materials that can be reused or recycled. Besides, it considers that the waste generator is responsible for managing this waste.

This Resolution has undergone changes over the years, such as the creation of Resolution No. 348/2004, which amends item IV of article 3, adding the consideration that materials containing asbestos are harmful to health. Resolution N^o. 431/2011 amends items II and III of article 3; Resolution N^o. 448/2012 amends articles 2, 4, 5, 6, 8, 9, 10, and 11 and revokes others; and Resolution 469/2015 amends item II and adds paragraphs 1 and 2 of article 3.

The aforementioned resolution states that waste generators must prioritize the reduction, reuse, recycling, treatment, and favorable final accommodation. These wastes cannot be disposed of in urban waste landfills or discarded in embankments water bodies, unregulated lots, and areas protected by law. Therefore, construction and demolition waste (CDW) must be treated, reused, and/or recycled.

In addition to the NEC resolution, the National Solid Waste Policy (NSWP) is also used, instituted by law No. 12,305, of August 2, 2010, and regulated by decree N^o. 7,404 of December 23, 2010 (12). This deals with the principles of industrial ecology and places among its main objectives the non-generation, reduction, reuse, recycling, and treatment of solid waste, as well as the environmentally appropriate final disposal of waste.

Currently, there are studies in the literature that report the use of residues in many stages of civil construction, such as obtaining mortar coverings (13–15), in pavements (16), and precast concrete (17).

In coating mortars, CDW can be used as fine aggregate, replacing natural sand in different percentages, presenting satisfactory performances (18).

1.1.3. Mortars

Mortars are important materials for the construction sector because, in addition to being able to join elements such as ceramic blocks or concrete blocks, they can be used as coatings helping to protect elements of a building such as walls, ceilings, and floors (19).

Mortars are usually made of Portland cement, lime, and fine aggregates (20).

The ABNT NBR 13529 (21) standard defines coating as “covering a surface with one or more layers of mortar, capable of receiving a decorative finish or constituting a final finish, decorative or not”, and the coating mortar is a “Homogeneous mixture of fine aggregate(s), inorganic binder(s), and water, whether or not containing additives or additions, with adherence and hardening properties”.

1.1.4. Patent Information

A patent is an authorization that gives the holder the right to control the use of an invention according to his claims within an area and for a limited period. After filing the patent, it is published by the World Intellectual Property Organization (WIPO) 18 months after the priority date, so it becomes available in international databases (22).

Law N^o. 9,279, of May 14, 1996, provides for rights and obligations related to industrial property and describes that an invention is patentable when it meets the requirements of novelty, or results in the improvement of an invention or the process of manufacturing (23).

A patent is a tool for disseminating information, as it can be used as a source of data for technological and economic development indicators, to accompany technological developments, and to identify holders of technologies and market trends (24).

In line with the development of new products, the search for knowledge on innovation in large databases has become a common practice in most organizations, due to the evolution of information technology. Patent data can show changes in the structures and development of a country's creative activities in technologies, industry, and companies. Patents can also indicate changes in dependence on certain technologies, in addition to their dissemination and scientific penetration (24). Patents represent a way of expressing a country's technological and financial growth to the market since it contains descriptions of inventions and their functionalities, which allows for analyzing the competitiveness between inventors and companies (25).

2. MATERIALS AND METHOD

This work's research is classified as exploratory. Exploratory research is used to obtain more information on the topic to be treated, and it is oriented in the formulation of hypotheses and is used in bibliographic research and case studies (26).

This work sought to evaluate the information found on the results of patenting technological routes for obtaining construction mortars using construction and demolition waste (CDW).

Data collection was performed from July to August 2020 using information available in the following international patent databases: Google Patents (<https://patents.google.com>), European Patent Office (EPO) through Espacenet (<https://worldwide.espacenet.com>), and World Intellectual Property Organization (WIPO) available on Patentscope (<https://patentscope.wipo.int>).

A model was used in the research to perform the technological mapping based on the steps of Paranhos and Ribeiro (27):

- Definition of the databases to be searched depending on the focus of the mapping.
- Construction of the scope for patent search, to guarantee the quality of the methodology used.
- Search and selection of documents retrieved for download.
- Removal of duplicates, repetitions, and false documents.
- Preparation of spreadsheets for statistical studies and qualitative considerations.

In the first stage, to catalog all available patents when using these descriptors, the keywords “construction and demolition waste” and “mortar” were used. In the second stage of the research, we conducted a survey on the number of deposits and publications over the years, as well as the countries with the greatest technological detentions related to the theme and the classifications in which the patents fit according to the International Patent Classification (IPC).

3. RESULTS AND DISCUSSIONS

The results obtained by searching the patent databases are presented and discussed below. When using the search terms “construction and demolition waste” and “mortar”, we found a total of 70 patents, excluding the duplicated patents in the different databases. These patent applications were organized according to the years of filing, publication, inventors and/or depositors, and office and/or country, and followed by a summary of each of the documents.

3.1. Patent Filing and Publication Over the Years

Figure 1 shows the number of patents filed according to the search term used. The earliest patent found was filed in 1993 and the year with the highest number of patent filings was in 2016 with a total of 14 deposits, considering the time of the research.

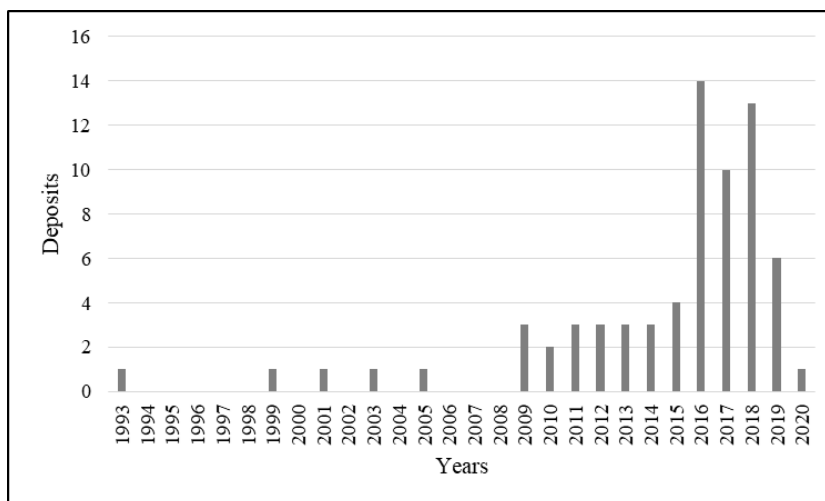


Figure 1. Evolution of the patent filing.

Source: Authors

Figure 2 shows the number of patents published from 1996 to 2020. When analyzing the graph, the year with the highest patent publication was in 2020, totaling 13 patents, considering the period of research.

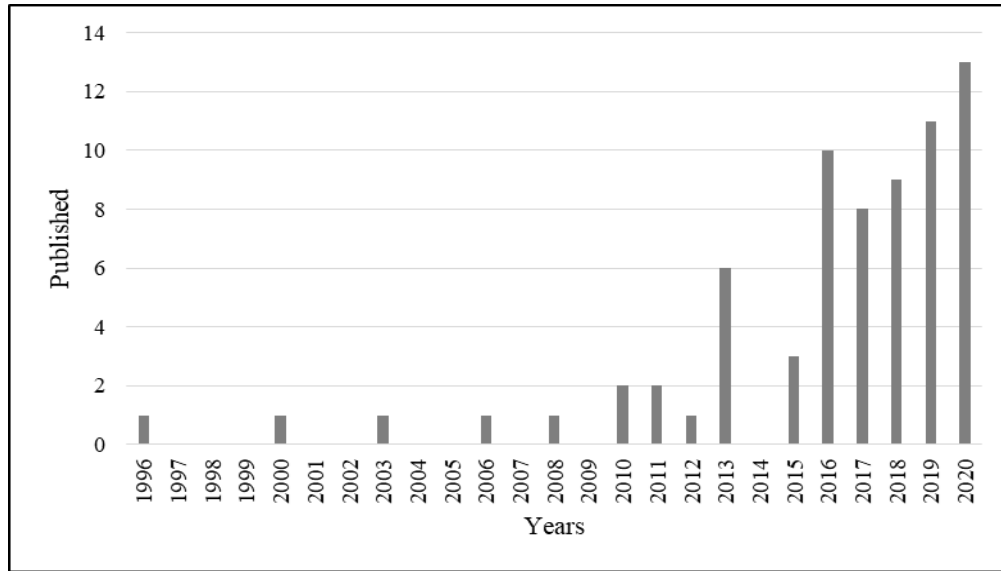


Figure 2. Evolution of patent publication.
Source: Authors

There is an increase in publications and patent filings in recent years according to figures 1 and 2. The divergence between the number of deposits and publications is due to having access only to the patents that have been published, that is, the number of patents published in a given year refers to the patents whose deposits have already occurred. For example, a patent that was published in 2020 had its filing before this period, so there may be patents filed in the year 2020 and previous years that have not been published and are not available for consultation.

3.2. Publication Offices / Countries

Figure 3 displays the number of patents deposited and/or published concerning the filing offices/countries. According to the figure, among the 70 published patents, the countries with the largest number of patents in Brazil, with a total of 21 patents, followed by the Czech Republic and Spain with 11 and 10 patents, respectively.

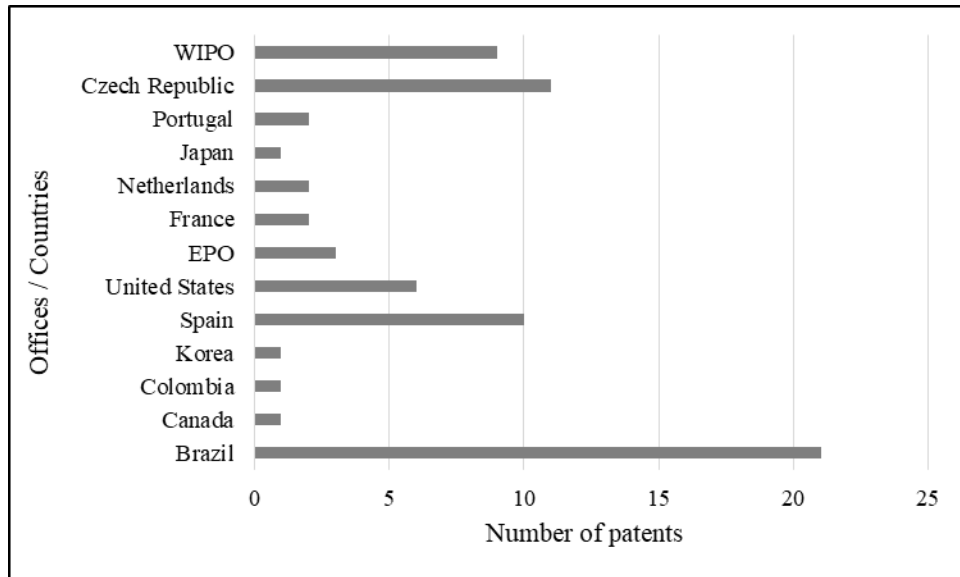


Figure 3. The number of patents found in the databases concerning the Offices / Countries.
Source: Authors.

The number of patents on the proposed theme may be related to the constructive culture of each region, such as Brazil, which usually uses conventional construction as a method, based on brick and mortar in general. Other countries can use wood as one of the main construction methods.

3.3. International Patent Classification (IPC)

The IPC can be used to restrict the search according to the segment, allowing the assessment of technological development in several areas.

Figure 4 shows the number of patents concerning the International Patent Classification (IPC).

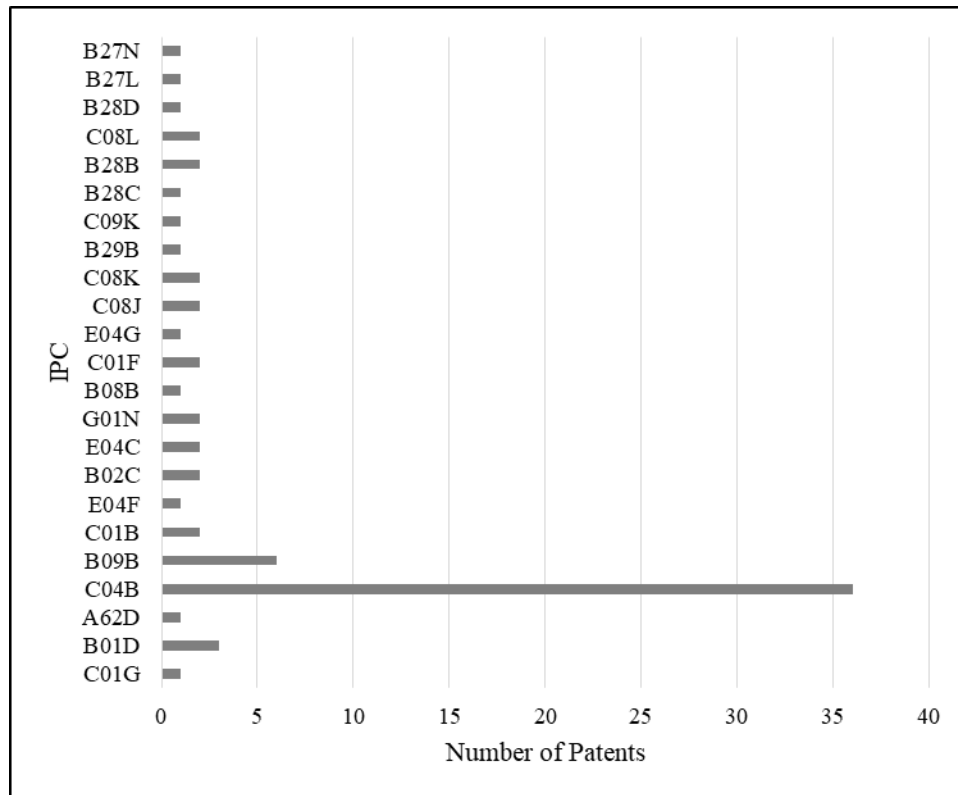


Figure 4. Number of patents concerning IPC.

Source: Authors.

The classification with the highest number of patents is in section C (chemistry; metallurgy), followed by class C04 (cement; concrete; artificial stone; ceramics; refractories), and subclass C04B (lime; magnesia; slag; cement; its compositions, e.g.: mortar, concrete or similar construction materials; artificial stone; ceramics; refractories; natural stone treatment), this classification had a total of 36 patents.

The second classification with the largest number of publications had a total of 6 patents being in section B (carrying out operations and transport), class B09 (disposal of solid waste; recovery of contaminated soil), and subclass B09B (elimination of solid waste).

These results are due to the keywords “construction and demolition waste” and “mortar” used in the search fields, as they are a theme that comprises building materials in general such as concrete materials, ceramics, and stones that are represented by classification C04B and residues that are represented by classification B09B.

CONCLUSION

Sustainability is increasingly related to innovation, and the three pillars of sustainable development (economy, environmental, and social) must be addressed. For this, searches for new technologies are essential and can be done by searching patent documents through international patent databases. Therefore, this study aimed to seek

information on technologies available in the Google Patents, WIPO (Patentscope), and EPO (Espacenet) databases, aiming at the use of construction and demolition waste in construction mortars. According to the search terms, the technologies found are being adopted more in the last 10 years. There was disagreement between the quantities of deposits and publications, as this is due to the fact of having access only to the patents that are published, that is, the deposits found are from patents whose publications have already occurred. Additionally, the study was conducted from July to August 2020, so by the end of 2020, there may be an increase in that number. The research has the potential to contribute to improving the strategy for using construction and demolition waste (CDW) in mortars. Future studies on the subject studied are suggested as an update of these technologies using the same term at the end of 2020 and the combination of different terms (descriptors).

CONFLICT OF INTEREST

The authors declare that they do not know financial interests or personal relationships that may have influenced the study reported in this article.

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