

# Chapter 22

## The Rehabilitation of Buildings from the Perspective of Circular Economy Principles



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**Abstract** The Material Bank (MB) of the city of Porto (Portugal) is an emblematic case that operates in the design phase of the rehabilitation of buildings from the perspective of the circular economy, acting as intermediation of information as a strategic resource in favor of the creation of a network of partners for the preservation of the old quarter with its historical and architectural heritage of the city. In this context, the study analyzes the actors, expectations and values with an emphasis on the circular economy and mitigation of construction and demolition waste. It consists of an exploratory-descriptive research, from qualitative nature, which uses bibliographical and documentary research to describe and analyze the Constructive Materials Bank of Porto City Council as a public policy capable of acting in the transition of the circular economy, noting that information is the key element in the mechanisms of reputation and trust, in the implementation of building rehabilitation projects and in the relationship between citizens and the city. The MB is an innovative model of public policy in managing and providing building materials of historical and architectural value. The idea is to align the heritage and cultural value of buildings with the principles of the circular economy.

**Keywords** Collaborators network · Circular Economy · Architectural · Material bank

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## 22.1 Introduction

Concerns about the future of the planet involve changing people's mindsets, the processes that stimulate these transformations and the way products and services are produced and used in their daily lives. Circular thinking applied to building materials will result in a more prosperous, livable and sustainable society, but it will require a radical rethink of all aspects of the production of the built environment. Circularity changes the very environment in which we live, work and invest [1].

Cities have a massive stock of existing buildings that are considered real banks of material resources and stimulating their rehabilitation can stimulate the creation of banks of building materials, acting to reduce the generation of construction demolition waste. The adaptations of existing buildings help to preserve natural resources and extend the life cycle of buildings [2]. Data from the European Union show that 85% of the existing building stock (more than 220 million) has its construction dated before the year 2001, and the majority (between 85 and 95%) of the buildings standing will still exist in the year 2050 [3].

Circular economy actions can deliver up to 60% reductions in material-related greenhouse gas emissions over the material-related greenhouse gas emissions over the life cycle of buildings [3].

In Circular Economy models, end-of-life building materials should be reused and their components and parts deconstructed, to act as material banks for new buildings, keeping the components and materials in a closed circuit [4]. Furthermore, buildings produce a quarter of the world's waste [4].

This research is part of a network project called "Circular Economy as a Strategy for a More Sustainable Construction Industry—EcoEico" (portuguese acronym) which, among other goals, seeks the "development of strategies for the implementation of the Circular Economy, aiming to encourage the development of an industry of more sustainable construction, especially in Ibero-American countries".

City councils in many cities provide information services to citizens with a view to introducing the principles of the Circular Economy. The old quarter of the city of Porto in Portugal is on the list of UNESCO World Heritage cities [5]. This fact makes it an intermediary of information for the preservation of the old quarter with its historical and architectural heritage. A good part of these activities are delegated to the attributions and competences of the Municipal Board of Culture and Heritage through a more specific body, called the Material Bank.

This research is motivated by understanding the Material Bank as a unit that operates in the design phase of rehabilitation of buildings from the perspective of the circular economy. In view of this, the idea of identifying with whom, about "what" and "how" the Material Bank engages with partners to implement its actions to disseminate CE principles. The discussion through the case study intends to prospect these partners, the stakeholders, and the strategy for creating and/or encouraging a "culture" in the construction industry, based on the principles of circular economy and sustainability. As limitations encountered during the preparation of the article,

we found that there is no quantitative data in the case study (MB) to allow justify the volume of materials that no longer go/went to replacement.

## 22.2 Background

### 22.2.1 *Circularity of Materials in Building Rehabilitation*

The verticalization of city centers to maximize and take advantage of the built area promoted a culture among investors and builders of demolishing to rebuild new buildings. Discussions related to reuse are joined by concerns about sustainability and the scarcity of raw materials, which raise the concern to stimulate the reuse of construction and demolition waste [6] on a large scale, reusing it in industrial areas, housing complexes, roads and shoots among others. Such actions, with an emphasis on the Circular Economy, bring together the different actors in the construction sector, such as: governments, builders, engineers and customers.

Materials in buildings should act as material banks as they are valuable products. This can be done using smart design and circular value chains, which is crucial for an industry to reduce its waste and the amount of virgin resources used. Therefore, a circular economy describes an economic system based on new business models which replace the perception of “end of life” concept by reducing, reusing, recycling and recovering materials in production/distribution and consumption processes with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations [7]. The transition to circular construction involves changes in value chains, from product design to new markets, from new models of consumer behavior to new ways of turning waste into resources. Knowledge and experience about reuse and reuse options for construction products and materials is very limited. The reuse of materials may require minimal processing before their reapplication in a similar context [8]. It should be added that the constructive environment lacks information regarding the type and quantity of materials used in buildings with a view to potentially increasing circularity at the end of the life cycle, which culminates in the proposals for material passports [9].

In the case of cities and historic buildings, digital inventories emerge as a heritage management strategy, expanding with identification data; research and analysis of historical value; asset impact assessment; planning research activities, conservation and handling of materials used; and provide information to the public on architectural and historical value, awareness actions aimed at authorities and decision makers [10]. These inventories are essential informational tools to make decisions, apply laws and policies related to heritage [10]. Investigations on the subject point out: absence of circular economy policies at building level—technical and social, need for more coordinated actions and policies to encourage circularity—laws and regulations, lack of political actions promoting recycling, reuse and new models of public and

private businesses—fiscal and economic incentives [11], lack of assessment of the environmental sustainability of circularity strategies—environmental and cultural and of enabling tools to promote circular supply chains and new production models—technology and economy [12–14].

### ***22.2.2 Strategy and Projects for Circular Economy Within Cities***

The importance of the circular economy (CE) leads to the stimulation of countless action plans applied in the creation of informational resources to manage and minimize the generation of waste in cities, increasing the efficiency and environmental performance of buildings. The transition from the linear economy to the circular economy within cities and institutions that provide services to citizens requires information and government policies for regulation and reduction in the taxation of materials or for the rehabilitation of existing buildings. For example, in the UK, taxes on new buildings are increased by up to 20%. On the other hand, the retrofit of the building is exempt from Value Added Tax (VAT). In Sweden, VAT rates are lower for renovations aimed at preserving unity. The Dutch government encourages the formation of partnerships to promote the design of new products inspired by circular business, through the program Realization of Acceleration of a Circular Economy—RACE [1].

The Building as Material Banks (BAMB) consortium has gathered some actions that provide information on “buildings as material banks” on its website, the challenges and perceptions regarding the circular economy in the built environment. In Denmark, a step-by-step tool has been developed that describes how to make the transition to CE and explains it in a local case study [15].

Another initiative is Circular Flanders as a Flemish government service responsible for waste, material and soil decontamination policies. This action aims to provide a hub and inspiration for the circular economy in Flanders. It is built from a partnership of governments, companies, civil society and knowledge institutes that act together. To this end, it promotes public tenders for city projects, businesses and circular purchases, launched the Green Deal ‘Circular Construction’ which brings together organizations that support circular economy actions in the built environment and Living Labs on ‘Circular Construction’ to support circular transition policies sectors either by experimentation or applied research [16]. The CityLoops project focuses on waste streams in Europe: Construction and Demolition Waste and Biowaste, and brings together seven small and medium-sized European cities—Apeldoorn, Bodø, Mikkeli, Porto, Seville, Høje-Taastrup and Roskilde. The idea of making cities circular is to eliminate all types of waste. The project proposes a digital material passport platform that aims to ensure that materials are recovered and traceable from demolition to their new uses. Passports store data such as a material’s

history, quantity, quality, estimated value, location, required maintenance, reuse or recycling potential, and instructions for disassembly and storage [17].

Another European Commission initiative gathered 71 practices in the Culture for Cities and Regions Project document, one of which is the Material Bank: capitalizing on architectural heritage [18]. The BAMB project stimulated the increase/sustaining of value in buildings through six tools: Material Passport, Reverse Building Design, Circular Building Assessment, Circular Business Models, Policies and Standards, and Pilot Case Studies [19]. These tools were underpinned by information and variety of stakeholders within the construction value network. It should be noted that the quality of this information results from the task of collecting, manipulating and exchanging digital data among stakeholders. But after all, which actors dialogue with the construction sector to promote the circular economy?

### ***22.2.3 Collaboration Network in Favor of the Circular Economy***

The aforementioned initiatives lead to the conclusion that a built environment, circular and reversible, can only be supported by a network of interconnected actors, that is, when relevant public and private companies in the construction industry work together, it becomes possible to create strategies to promote of the economy. Actions to reduce, reuse and recycle building materials are a temporary way to materialize investments and expand opportunities for exploring circular business models, in which economic and environmental value is conserved. It is noteworthy that the government is an active actor that helps with tax incentives that require low resource input and that facilitate the circulation of materials in the sector and accelerate the socialization and education of citizens and other actors in the adoption of the circular economy.

Perception/awareness about the CE concept, practices and transition, as well as managing this process, requires the creation of a network of collaborators that includes researchers, academics, policy makers, companies, workers, employees, consumers and others [20]. Organizational actors and society, in general, agree with the implementation of institutional and/or governmental guidelines as instruments to encourage CE in the construction, renovation and use of housing [21].

In the opinion of survey respondents [21], the most valuable actors to drive sustainability in housing are funders, followed by inspectors and government interventions. This reveals the opportunity for governments to exercise their legal powers to implement measures aimed at implementing these three types of instruments (financial, fiscal and government interventions) and their interest in doing so. These policies involve decisions at different levels of government—local and/or central—, which must act in a coordinated way in their measures to promote sustainable construction. On the other hand, in terms of government intervention, public policies should be based on priority, on technical support mechanisms, on the implementation of

support tools for housing projects, on facilitating access to databases and on granting subsidies for finance public services [21].

### 22.3 Methodology

Research is exploratory-descriptive, of a qualitative nature, in which bibliographical and documentary recovery was used as a technique to describe and analyze the Materials Bank of the city of Porto. In this way, we sought to identify elements concerning the strategic function of the information that describes and analyzes the Bank of Constructive Materials as a public policy that acts in the promotion of CE and identifies the interested parties. The investigation explores partner and collaborator engagement practices that facilitate the dissemination of CE principles [22].

### 22.4 Material Bank of the City of Porto

The World Heritage List by the United Nations Educational, Scientific and Cultural Organization (UNESCO) brings together cities and the set of properties of Outstanding Universal Value (OUV) that it highlights as a cultural and/or natural value that transcends borders with a focus on current and future generations of all mankind. Climate changes caused by the intensive use of raw materials call for public policies to value processed products and reduce the scale of materials [5].

Historic cities such as Porto—being a UNESCO heritage site since 2001—need policies for the rehabilitation of their buildings, so that future generations can understand their origins and learn to value the achievements that are part of the strategic objectives of the Committee of the World Heritage: Credibility of the World Heritage List; Effective conservation of World Heritage properties; Effective competences in the States Parties; public awareness, participation and support for World Heritage through Communication; and Communities in the implementation of the World Heritage Convention [5] (Fig. 22.1).

The actions focused on the preservation of the OUV building act on the reduction of construction demolition waste. At the moment, it brings together professionals from architecture, engineering, history, archeology and restoration, in projects of national and international interest (organizational, institutional collaborators and society). UNESCO guidelines and the attributes present in non-monumental buildings—residential housing—also contribute to the OUV of Architectural Good: constructive systems—of buildings, circumscribed by walls, based on foundations and walls of local stone, with floors in wooden beams, in some cases resorting to structures made with a lattice on wooden beams; and materials and techniques: and landscaping of the set using materials and construction techniques, with emphasis on the worked stonework, the sloping, coated and ceramic roofs, wooden window



**Fig. 22.1** Distribution map of ceramic elements in CHP/PM-2007 [–5]

frames, wrought iron elements, and the tile heritage (in the cladding facades and inside), skylights, fresh air and ceilings.

The Material Bank is a unit subordinated to the Municipal Board of Culture and Heritage and its principle is to preserve Porto’s buildings, with their historic tiles—Hispano-Arabic—from patterns from the 17th to the twentieth centuries, such as: the panels in cobalt blue from the nineteenth century, artifacts of stonework, iron, wood and toponymic plaques collected on the public road. It should be added that it acts in the custody, preservation, restoration and return of building materials to the city in the rehabilitation of facades with the same topology regulated on December 16, 1999, by Decree-Law 555/99, as a public policy and “mechanism of protection of the tile heritage of the city of Porto”.

The MB, by playing the role of preserving the architectural and historical heritage, participates as an important factor in intermediating the rehabilitation of buildings that favors project management and the relationship with employees. Citizen service is an activity that requires interactions with the actors in the environment and all the groups that are around them, who are implicitly or explicitly interested in their results, or tasks (technicians, architects, engineers, builders, among others). As a public institution, the unit offers services to the citizens and, therefore, any and all actors or groups that have an interest and influence in the processes of rehabilitation of the historical, architectural and cultural heritage of the city of Porto.

MB employees are actively involved in mapping the architectural and cultural heritage of historic buildings and works that are part of the city’s memory and identity, recording, organizing and archiving the constructive elements that tell the city’s history, providing guidance to professionals in the architecture and construction



engineering such as lectures and a workshop to support the restoration project of historic buildings, recovery of decorative objects characteristic of Porto architecture (tiles, iron and stucco, etc.), management and physical and documentary storage of construction elements, information for tourists, young people, children and citizens on the heritage and architectural value of the materials that characterize the city's image, management in the donation of recovered elements free of charge to residents, among others. The information and building materials on the storage and management of the unit make it possible to generate indicators for the reduction of construction demolition waste, with an emphasis on reuse, reduction and recycling as one of the first fruits of the circular economy. Furthermore, this information makes it possible to create value in the buildings where the materials are used.

This study will consider the MB as an organizational actor—even though it is an institutional actor—that brings together a network of partners and/or collaborators in a mediation relationship in all services. Reasons that motivate the evaluation of organizational management, while seeking to identify the specific needs or benefits of these actors, respecting the actors (Porto City Council), other government bodies, society—students, professionals, universities, researchers, tourists, etc.—, and competing companies.

Table 22.1 presents an inventory of who are the main collaborators or potential partners, whether they are individual actors or groups, with a positive or negative opinion due to their particular interests. The public managers of the city of Porto, as employees of the material bank, take care of the materials that beautify the city. Investments must be raised with institutions for the management of documentation in the generation of a passport of matters of buildings in historic cities, allowing in the future the monitoring and exchange of building materials between citizens and perhaps cities. It appears that the team encourages design for disassembly and recyclability of materials removed from housing, whether reintegrated into the same building or repositioned at other points.

## 22.5 Conclusion

The MB works with an emphasis on preserving the historical and cultural heritage of the city of Porto, but the focus of this investigation is how these actions approach the citizen's awareness of the principles of the circular economy. It is important to highlight the alignment of policies, strategies and projects with the search for circularity in construction materials. The MB faces barriers with internal and external actors involved in the construction value chain. The network of MB collaborators has the support of public managers, inspectors, entrepreneurs, builders and citizens who work to expand actions that favor the circularity of buildings and prolong the life cycle of construction materials.

Table 22.1 shows who is part of the network of MB collaborators and the perception of this investigation regarding the expectation and the desired value when involving these partners to implement the actions of the EC principles associated



**Table 22.1** The actors, expectations and desired value in relation to the circular economy

Actors		Expectation	Desired value
Organizational Material Bank	Public Managers Collaborators Internal partners	<ul style="list-style-type: none"> <li>– Preservation of the historic and architectural heritage of the city of Porto</li> <li>– Encouragement to reduce, reuse and recycle constructive materials</li> <li>– Planning to comply with public policies related to the unit</li> </ul>	<ul style="list-style-type: none"> <li>– Beautification of the city and generation of income with rehabilitation of buildings</li> <li>– Attenuation of construction demolition waste</li> <li>– Competitive intelligence on good circular economy practices</li> </ul>
Institutional Porto City Council	Government Partners Financiers	<ul style="list-style-type: none"> <li>– Support for rehabilitation projects that encourage reduction, reuse or recycling, increasing the life cycle and adding value to building materials</li> <li>– Undertakings for Historical and Architectural Inspiration of cities</li> <li>– Structuring based on digital technology</li> </ul>	<ul style="list-style-type: none"> <li>– Promotion and generation of citizen, sociocultural and circular economy knowledge</li> <li>– Good knowledge management practices to guide decision-making by project</li> <li>– Shared management—speeding up retrieval of information and indicators</li> </ul>

(continued)

**Table 22.1** (continued)

Actors		Expectation	Desired value
Society	Universities, Environmentalists and Partners Builders and Real Estate Engineers and Architects Tourists—Historians and Students Municipalities	<ul style="list-style-type: none"> <li>– Technical information that guides the suitability of the building with a focus on the 3Rs</li> <li>– Dissemination and encouragement of historical and architectural culture</li> <li>– Dissemination with professionals and academics in university training</li> <li>– Improving assets by meeting tax obligations</li> </ul>	<ul style="list-style-type: none"> <li>– Storage of technical knowledge and experiences</li> <li>– Educational and training practices focused on rethinking the use of construction materials</li> <li>– Assistance and guidance on good practices with a focus on the 9Rs (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recover)</li> <li>– Increase public and private participation</li> </ul>
Contestants	Competitors and Detractors	<ul style="list-style-type: none"> <li>– Brand Management in contrast to companies with similar nomenclature</li> </ul>	<ul style="list-style-type: none"> <li>– Highlight for competence, ethics and social responsibility</li> </ul>

with the historical and cultural heritage value. The study leads to the assimilation that the MB has a lot of information about materials and systematized projects of interests of the Municipality of Porto (Skills and attributions). It notes that information is the key element in the mechanisms of reputation and trust (Credibility), in the implementation of building rehabilitation projects (Conservation) and in the relationship between citizens and the city (Community). Although, the discussion on the heritage and cultural value of building rehabilitation promotes the principles of the circular economy (Communication—public awareness). MB action also furthers the World Heritage Committee’s strategic objectives. All of this, even in the face of the challenges faced by the lack of awareness on the part of builders.

It should also be noted that the MB team offers training workshops for professionals, students and citizens with a focus on tile heritage and on the identity building elements of historic buildings, which also encourages CE. It is concluded that the MB indirectly acts in the transition from linear to circular economy, involving citizens and beautifying and preserving the city, establishing partnerships with other internal actors of the City Council and the citizens. The MB is an innovative model of public policy by managing and providing construction materials of historical and architectural value, which modifies citizens’ behavior regarding the importance of rehabilitation and the application of the principles of reducing, reusing, recycling as a decision strategy in the adoption of construction methods with secondary materials arises based on the perspective that material resources are finite.

The expectation is to adapt these actions to local contexts related to the Circular Economy in the construction sector for Latin American countries, considering their social, economic and cultural differences in different realities.

For future articles, we propose research on two axes of analysis: 1—analyze the existing laws and regulations for the treatment of solid waste (construction and demolition waste) and the entities responsible for verifying their compliance; 2—Evaluate, through LCAs or ecological footprints, the evaluation of the environmental impacts mitigated by the actions of the Material Bank.

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