



The before and after of rail infrastructures in Paris.

Reusing railway infrastructures in the spirit of circular theory. A contribution to an operational concept

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Abstract: This paper aims to be a contribution to the proposal that the reuse of obsolete railway buildings can also be considered in the field of circular construction and circular architecture. Recent discussions argue that to consider circular economy only as the reuse of materials or the reduction of waste is a misconception. The reuse of buildings is also an issue in circular theory. The European Union itself, since 2002, supports the Programme ESPON - European Territorial Cooperation Programme, which incisively inserts obsolete buildings in the “spirit of the circular economy”, giving greater attention to industrial areas undergoing change and deindustrialisation. Considering that the concepts of circular construction and circular architecture derived from the circular economy, which emerged as a way to promote and ensure urban sustainability, this article addresses in a first moment the concept of circular construction from the first documents developed in the context of sustainable development until the latest policies proposed by ESPON. It also analyses the reuse of obsolete railway spaces based on the analysis of some emblematic examples of reuse, namely the *Musée d’Orsay* and the *Promenade Plantée* in Paris. These two examples represent different types of railway infrastructure, and their currently use will frame the reuse of railways within the concepts of circular construction.

Keywords: circular construction; sustainability; railway heritage; reuse; restoration; France.

1. Introduction

If the industrial revolution characterized the 19th and 20th centuries, we consider that sustainability characterizes the 21st century. Architectural projects - which in the past valued the new materials that emerged and the use of new construction techniques - are currently inspired by new digital technologies – circular architecture - and the emerging concept of circular construction.

In 2020, the European Commission adopted a new Action Plan for the Circular Economy with a series of initiatives including “a comprehensive strategy for the sustainability of the built environment that promotes the application of circularity principles to buildings” (European Commission, 2020).

This concern has forced a rethink of the way buildings are constructed and reused. In fact, as Rand Askar and Luis Bragança (2019) state, buildings usually become obsolete after 20% to 30% of their potential lifetime and, for this reason, these authors consider that the “construction industry needs to change its linear and static ‘extract-produce-dispose’ thinking to a circular economic system, in which each material is used and reused to the maximum with the least waste” (Askar and Bragança, 2019).

To achieve this, they propose the construction of reversible buildings in which each material has a “passport” that identifies it and facilitates its later use in another context.

In 2002, the American architect William McDonough and the German chemical engineer Michael Braungart published the book-manifesto “Cradle to Cradle”, which aims to take buildings out of the “life cycle” model, defined in biology “as a linear cycle” (birth, use and disposal), and insert them in a “circular system”, extending their period of permanence and use to an indefinite period of time.

The interpretation of architecture and urbanism from a biological perspective is not recent. In the work “Cities in Evolution. An Introduction to the town planning movement and to the study of civics” (1915) written by Patrick Geddes, urbanism was framed in theories such as Darwin’s thermodynamics and evolution, defining the city and its planning as an open and living system.

The methodology proposed by McDonough and Braungart was applied in companies such as Puma, Philips and Alcoa, in urban studies for regions in China, Holland and Denmark, and in the inspirations of the projects developed for the NASA Sustainability Base Building and the Ford River Rouge Building.

Another initiative in this area was the development of the European BAMB Project (Buildings as Material Banks) between September 2015 and February 2019. This project included fifteen partners from seven countries. Its objective was to:

(...) the prevention of construction and demolition waste, the reduction of virgin resource consumption and the development towards a circular economy through industrial symbiosis, addressing the challenges mentioned in the Work Programme on Climate action, environment, resource efficiency and raw materials. The focus of the project is on building construction and process industries (from architects to raw material suppliers) (European Commission, 2019).

However, the prevailing view and aims to establish principles and standards to circular economy is still focused on buildings under construction and to be constructed in the future, how can we reinforce the reuse of old buildings in the new concepts of circular theory? The truth is that there is a whole series of industrial buildings that are largely deactivated due to the evolution and transformation of the economy, which originated new forms of production and the relocation of a large part of the industries that, until then, were characteristic and sustaining the economy of certain regions.

This deindustrialisation that occurred mainly in certain regions of Europe led to the abandonment and destruction of numerous industrial buildings. In parallel, the technical development verified for transport, namely the railway, associated with the public policies applied in the implantation and use of these means of communication, also led to the deactivation of numerous railway structures.

Some of these structures were managed to prolong their useful life by reconversion to new uses, others lie abandoned or were destroyed. The implantation of railway buildings in city centres resulted in the extinction of large stretches of railway lines, many of which stretched right into the heart of the cities. Their infrastructure generated spaces that, following the deactivation of the buildings and rails, became an issue to be discussed as spaces that could be totally changed or reused.

In many cases it was the cultural value of the deactivated railway system that prevented its total disappearance. However, nowadays, with the concern of achieving a sustainable urban development, the reuse of these buildings deserves to be considered within other concepts. Thus, to insert railway buildings in the spirit of circular construction and circular architecture, this paper

brings some theoretical reflections followed by important examples of reused and revitalised railway areas, seeking to be a contribution to the framing of this infrastructure in the most contemporary concepts of circular theory.

2. The reuse of buildings, circular construction and circular architecture

According to Gomes, Bernardo and Brito (2005), the initiative that preceded the elaboration of the concept of sustainable development occurred in 1972 at the United Nations Conference on the Urban Environment, also known as the Stockholm Conference. In the document produced at this conference, twenty-six principles for sustainable development were drawn up, in which the key concerns focus on natural resources, the human environment, demographic growth and the natural environment.

However, the origin of the concept of Sustainable Development is the Brundtland Report (Our Common Future), prepared in 1987 at the World Commission on Environment and Development. On Chapter 2 of this document, there is a sub-chapter entitled "The Concept of Sustainable Development". The fifteen points that are developed to explain sustainability include concerns about natural resources, consumption habits, social inequality and the growth of the urban population. All these concerns aim to respond to "the needs of the present without compromising the ability of future generations to meet their own needs", an idea that is the pillar of sustainable projects until nowadays.

As a follow-up to this document, in 1992 during the United Nations Conference held in Rio de Janeiro (Brazil), Agenda 21 on Environment was developed. This document refers to the importance of consumption habits in the strategies adopted to achieve sustainable development. One of the other aspects focused on in the document is the need to reduce industrial production and the use of natural resource. Referring only to the reuse and recycling of materials, the reuse of buildings is not yet mentioned.

Although the concept of circular economy started to be developed in 2015 (Paio, 2021), it is already possible to see its basic concern - of reusing and recycling materials to reduce the use of natural resources - presented in Agenda 21.

According to Röhm, Neto and Röhm (2013), construction waste represents about 54% and 70% of municipal waste, which justifies the advent of the concept of circular construction, concerned with the reduction not only of

the use of natural resources, but also with the reduction of construction waste.

Features of buildings and structures, such as durability, the possibility of modernization and reuse predispose them to apply circular concepts – closing economic loops, so that the goods circulate as long as possible with simultaneous value maximization. (Bukowski and Fabrycka, 2019).

Another way to control waste produced by the construction industry is very recent and has been giving way to the concept of circular architecture. This, in turn, for the "promotion of reuse, reduction, recovery and recycling" (Paio, 2021) of materials, makes use of digital fabrication. As cited by Paio's (2021) opinion article in the newsletter "O Jornal Económico", 3D printing is the best-known digital manufacturing that has already been enabling the production of prototypes and complex parts combined with lower waste production, as it allows objects to be modified without the need to be discarded.

Since the first initiative for sustainable development, we could see that demographic and urban growth are an ever-present concern, in addition to the aforementioned issue of reuse and recycling of materials. However, even in the most recent documents, namely Agenda 2030, the control of urban growth is a concern referred only as a responsibility of the various public institutions.

Recently, the European Territorial Cooperation Programme ESPON, created in 2002, published a policy brief on the reuse of buildings and spaces as a sustainable solution to help control urban growth. Over a period of eight years, an increase from 19.2 million to 22.6 million hectares of artificially occupied land on the European continent was recorded.

Reusing spaces and buildings can be seen as an effective way to reduce urban sprawl and its environmental impacts and to keep neighbourhoods occupied and vital. It is considered an attractive alternative to the construction of new buildings or using non-sealed soil. In the spirit of a circular economy, industrial areas in transition and deindustrialisation deserve particular attention (ESPON, 2020).

Within this new perspective, although the sustainability concerns be more focused on urban growth and development, at the scale of the object receiving intervention, we cannot fail to consider it as a more comprehensive application of the concept of circular construction and circular architecture that can aid the cities to achieve a sustainable urbanism.

During the second half of the 20th century the reconversion became an important tool to deal with disused urban infrastructures. After the Agenda 21, some other documents were developed on behalf of the sustainable urban design, like the Charter of European Cities and Towns towards Sustainability (1994), EU Framework Directive on ambient air quality (1996) and the European Spatial Development Perspectives of 1999. All of them were used as references for the Lille Declaration (September 12, 2000). This document looks towards a “European Greenways Network”, by reconverting old infrastructures in greenways.

This document took into account the demands made for the provision and development of services to: facilitate non-motorized travel (to reduce congestion, noise and air pollution); design spaces for low-risk leisure activities (accessible to all and with beneficial effects to public health); encourage sustainable tourism; conserve and enhance local heritage and natural landscape; facilitate intermodal transport; and to increase the quality of urban and suburban life. The disused railway lines are quoted in this document as one of the highly suitable resource for the construction of greenways.

Like several other industrial infrastructures, railway buildings, often located inside cities, occupy a large area of urban land, which is even larger if we consider the land crossed by the rails and other railway infrastructures.

Vacant buildings could be either adapted to new circular industrial and non-industrial uses or transformed into public and urban planning. In the process towards sustainable urbanisation, green infrastructure, i. e. incorporating green (and blue) spaces and other physical features into terrestrial and marine areas, can be a useful tool. Green infrastructure contributes to the environment vitality of urban areas and can reduce energy use for heating and cooling buildings by providing shade in summer and shelter in winter (ESPO, 2020).

Although this may be a recent extension of the concept of circular construction, we can consider that “repairs, real estate trade, sharing or renting rooms have been taking place for hundreds of years” (Bukowski and Fabrycka, 2019), implying the potential role of the reuse of buildings in the market.

The architectural projects that have reconverted these former industrial zones into housing, office areas, cultural areas or green spaces, are examples of circular construction. In fact, these architectural projects involve the reuse of an old building, by maintaining its essential structure, and reusing its materials. The materials, could be also moved for another place to be reused in a new

architectural project, but like that, their reuse would be less efficient, due to a possible waste produced during their removal, and to the mean of transport that would be necessary.

The concerns with environmental issues that have marked the international political agenda are elements present in these projects for the recovery and reconversion of old buildings and industrial areas. Currently, beside the circular construction, the circular architecture can be added to these initiatives, due to the new technologies that can be used during the development of new architectural plans.

Urban planners and architects who seek to reuse buildings and industrial areas must bear in mind that their work and their projects also aim to reclaim normally degraded areas with poor health conditions, which should be returned to the city within an urban and environmental framework that corresponds to the standards advocated today for urban spaces and urban environment.

In this way, revitalising, refurbishing and reusing are practices that can also be found when the subject is focused on obsolete railway areas. A practice that we will illustrate below by presenting some long-known projects of reused and revitalised railway buildings and spaces.

3. Railway and urban spaces: reuse and memory

To insert the reuse of railway infrastructure in the concept of circular construction and circular architecture, we will analyse an example of reuse of a railway building and an example of the reconversion of a railway space into urban space. Different cases in Paris (France) were chosen due to the fact of being in the same urban reality, so the approach would not bring too many issues in conceptual, political and geographical terms (Cardoso de Matos and Lourencetti, 2017).

The French railway system is a benchmark in terms of operation and use. A large part of its railway stations and rails have been extended and re-adapted to receive the new railway technologies. Due to that, many buildings and railway tracks have been reconverted to another use or completely abandoned.

France had been inventorying its railway heritage since 1984; this country reached the high number of railway stations inventoried between 1986 and 1990. In the case of rails inventory, the high number was reached between 1996 and 2000 (Simon, 2009).



Figure 1 | View of the nave of the Gare d'Orsay. Source: Wikimedia Commons (accessed 2 April 2020).

It cannot be stated that this survey has a direct relationship with the most used ways of preservation in the country, as there is a wide variety of railway heritage buildings reconverted to other uses. On the contrary, we can affirm that the recognition of this infrastructure has fostered the preservation of several buildings. However, the concern with the urban landscape was also a reason for the versatility of the reuse projects implemented, a subject that cannot be disregarded.

Musée d'Orsay

The *Musée d'Orsay*, located in Paris, functioned as a railway station until 1939, when the building was no longer able to accommodate the new railway technologies and it was closed down.

In 1973, the old station was almost demolished, eventually being converted in 1980 into a space for artistic manifestations (Jenger 2006; Plum, 2007). The 137 metres

long by 40 metres wide nave was essential in shaping its new use.

Of the various discussions that took place about the interventions made to convert the *gare* into a museum, Jenger (2006) states that there was a fear of destroying the Orsay Railway Station building, because they did not know what would be appropriate to build on such a prestigious site. The building is located in the centre of Paris, and its great size and architectural richness were essential criteria for its preservation.

Its importance was based on its value as railway heritage due to its architectural features, as it is one of the first buildings constructed in iron, although its structure was clad so that the architecture of the station followed the pattern of Parisian architecture of the time.

This building was chosen in the moment that a new space to exhibit the Impressionist painting of *Jeu de*



Figure 2 | View of the nave of the Gare d'Orsay converted into the Musée d'Orsay. Source: Wikimedia Commons (accessed 2 April 2020).

Paume Gallery was supposed to be found. With this decision:

Une double gageure imposait une part transformer une gare en un musée d'autre proposer au public un musée du XIXe siècle soit une vision cohérente pour art une époque que on connaît encore bien mal (Jacques, 1986).

The project was entrusted to the studio of the architects Renaud Bardon, Pierre Colboc and Jean-Paul Philippon, founders of the ACT Architecture office in 1972. These professionals sought to follow a new approach to heritage - the "Métamorphose de l'Objet Architectural" (Atelier Jean Paul Philippon) - which had three essential axes:

- the city as a work in constant metamorphosis from which each building suffers the effects of its transformations;

- the legitimacy of transforming buildings and recycling them;
- the dialectic between pre-existing architecture and contemporary additions as the generator of new architecture.

The project of these architects was the winner of the competition for the transformation of the station in 1979 and sought to respond:

(...) à l'immensité de l'ensemble à l'échelle des œuvres exposées, il remodelé le grand volume sous verrière de l'ancienne gare et une succession de salles et galeries reparties sur deux niveaux le long d'un cours central incliné à partir duquel le visiteur peut s'orienter librement (Atelier Jean Paul Philippon).

According to Jenger (2006), the museum that replaced the railway use of the building was conceived with an area



Figure 3 | Musée d'Orsay. Source: Second author's photo (2015).

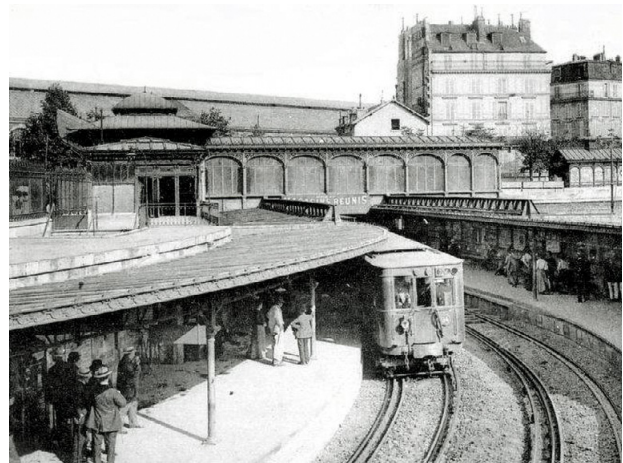


Figure 4 | Gare de la Bastille. Source: Wikimedia Commons (accessed 2 April 2020).

of 43000 m², being only 13000 m² of this plan an area obtained with the use of the old railway station. To obtain the missing area, 30000 m² of landings were built.

Although the reason for reusing the building has not been discussed as part of a sustainable strategy, we believe it is not possible to analyse this case today without considering it as an example to be inserted in the concept of circular construction. The amount of demolition material and even the number of raw materials saved in the reuse of this building is patent, being it one of the most visited buildings in the world.

Promenade Plantée

In 1859 (Gonzalex Campaña, 2002), an extensive railway line crossed the 12th arrondissement of Paris, from *Place de la Bastille* to the *Jardin de Vincennes*. One hundred and ten years later this railway line was deactivated (1969), and the Paris-Vincennes section was integrated into the RAR A (You, 2018).

In 1998, this area gave rise to what is now known as the *Promenade Plantée*, consisting of a linear garden designed by landscape designer Jacques Vergely and architect Philippe Mathieux; the rehabilitation of a viaduct that was a part of the railway infrastructure was designed by architect Patrick Berger (You, 2018). This is a 16-acre area enveloped by the city, which gave rise to the world's first railway infrastructure reconverted in an elevated garden.

A stroll above the roofs of Paris shows not just splendid vistas. It shows also how easily Paris could have demolished what it fortunately saved; how transportation in eastern Paris is becoming environmentally

friendly; how the restoration of the *Promenade Plantée* has also restored the neighbourhoods beneath it; how what seems a potential cost can become both an asset and an originator of wealth for an entire section of the city, and how raising money and taking advantage of private funds can make such a project feasible (Gonzalex Campaña, 2002).

The implementation of this linear garden transformed an impoverished and unhealthy area of Paris, due even to air and noise pollution produced by the railway system, into an urban area of great value.

Considering the triad of sustainable development - economic; social; environmental - we realize that the implementation of the Parisian elevated garden, fulfils all the requirements requested to be inserted in such practice. In terms of construction waste reduction, the demolition of a heavy brick viaduct was avoided by using it to build shops and a park, not to mention the influence on the surrounding area.

Since its creation the neighbourhood has seen the addition of 75,000 square feet of new commercial space and more than 200,000 square feet of office space. Another key to the success of this linear garden was that much of the length of the *Promenade Plantée* was soon surrounded with new housing (Gonzalex Campaña, 2002).

On the other hand, in 1982 the *Gare de la Bastille* was decommissioned along with the line and demolished, as its small size was not able to accommodate new technologies and uses of rail transport.



Figure 5 | . *Promenade Plantée*. Source: Twice25, CC BY-SA 3.0. Wikimedia Commons (accessed 2 April 2020).

Therefore, unlike the *Gare d'Orsay*, its building was not valued as an architectural monument, giving way to the new building of the "Paris Opera", inaugurated in 1989, occasioning the disposal of waste from the demolition of an old building and the use of new materials for the construction of a completely new one on the same site.

4. Embedding the spirit of the circular theory

As mentioned before, it is not by chance that we presented here such distinct cases of railway heritage reuse. The reuse of a railway building and the reuse of an urban space occupied by rails caused several impacts on the urban grid.

According to ESPON (2020), the urban growth in France is usually higher in comparison to the population

growth, which causes a diffused urban sprawl. In this case, the examples of reuse of old railway infrastructures end up highlighting a possibility to reverse this situation. Both cases enhance urban development in already urbanised areas, what can be framed within what ESPON (2020) defines as "Compact Urbanisation".

Throughout the ESPON (2020) policies, several cases of port regeneration are mentioned, namely Le Havre, Brest, Calais and Dunkerque in France. These cities had large extensions of their urban territory transformed after the deactivation of their old ports' infrastructures. As their port areas, the impact of some deactivated railways also resulted in the implementation of regeneration projects, and these cases should also be highlighted as examples of industrial areas in transition, and as a deindustrialisation inserted in the challenges of achieving a sustainable urbanism.



Figure 6 | . *Promenade Plantée Viaduct*. Source: Jeanne Menjoulet from Paris, France, CC BY 2.0, Wikimedia Commons (accessed 2 April 2020).

The *Musée d'Orsay* analysis focus on the reuse of a railway building that lost its former function and was reconverted into a space for artistic manifestations, “contributing to regenerative spatial and urban planning” (ESPO, 2020). Its reconversion avoided the construction of a new building, reducing the waste disposal, and the need for a new contingent of raw materials or the consumption and transportation of new construction materials.

Along with this, the reuse of this building had a positive urban impact, revitalizing the surrounding area and increasing the life expectancy of the building. Furthermore, the museum attracts around 3.5 million visitors per year, which contributes to the local economy. Like this, as the *Promenade Plantée*, the reuse of the railway station building fulfils the triad of sustainable development - economic; social; environmental.

In the case of the *Promenade Plantée*, the urban impact of the revitalization project is more evident. Even though it does not have the length of a greenway, this linear garden turned an industrial area into a green space, accomplishing all the demands covered by Lille Declaration in an urban scale. Thus, the reconversion of these old rails matches with the ideas of sustainable urban plans, contributing to the environmental vitality of urban areas by providing new green areas in Paris.

Moreover, as already mentioned, the implementation of the linear garden has made the 12th arrondissement of Paris gain a new value and a new life, contributing to the economic growth of its surrounding areas.

The reconversion of the railway infrastructure into a museum or into a linear garden may not have required the environmental decontamination that was necessary in the regeneration of several port areas, but the

reconversion of these infrastructures resulted in great improvements of the urban environment.

5. Final Considerations

When analysing the cases of the *Musée d'Orsay* and the *Promenade Plantée* we identified in the preserved elements an interest based predominantly on their cultural value; in the case of the old railway station, the building preservation was mostly related to its architectural value.

However, in both cases the urban impact was taken under consideration during the design process; due to the centrality of the old railway station in the urban fabric of Paris, and to the potential of the area crossed by the old rails in the improvement strategies of its surrounding areas.

Making use of these examples, some of the concerns currently linked to sustainable development were identified in the reuse projects. The issues related to the reduction of construction waste and the increase of the life cycle of buildings were reached in these reused infrastructures in an unconscious way. On the other hand, even if the concern for the railway heritage seems to be the principal reason why these places were preserved, the railway memory associated to them was almost totally erased by their new use.

Only recently the *Musee d'Orsay* started to be concerned to the building's past history. In the case of the *Promenade Plantée*, people cannot identify the pre-existence of rails right away if they do not know the history of that arrondissement or of the French railway.

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The *Promenade Plantée* has already influenced the reuse and revitalisation of other railway infrastructures in the urban environment, notably the High Line in New York. Thus, as an answer to the question posed in the introduction of this article - how can we reinforce the reuse of old buildings in the new concepts of circular theory? - we consider that the insertion of examples such as these two in more contemporary concepts will establish their reuse in a broader area than the one focused on their valorisation and cultural preservation.

There are several examples of railway infrastructure reused around the world that have had similar or even greater impacts than the ones brought here. Thus, with the study of *Gare d'Orsay*, *Promenade Plantée* and further other examples of railway infrastructures, we aim to contribute to the discussion of the integration of the reused railways in circular theory. Embedding the reuse of railway heritage in the spirit of circular construction and circular architecture can influence greater reflection on the responsibility to promote the development of a more sustainable urbanism in the design of future projects.

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