International Journal of Education and Humanities
ISSN: 2770-6702 | Vol. 18, No. 2, 2025

Construction for Urban Renewal: A Study of the Application of Assembled Buildings in the Reuse of Industrial Heritage in the UK

Yawen Yin*

Manchester School of Architecture, Manchester, M1 5AL, UK
* **Corresponding author**: Yawen Yin

Abstract: This dissertation explores the potential of assembled buildings in the adaptive reuse of industrial heritage buildings in the UK. The study employs a mixed-methods approach, involving qualitative and quantitative data collection and analysis. The key findings indicate that assembled buildings can be effectively integrated into the reuse of industrial heritage in the UK, addressing aspects of economic, social, and environmental sustainability. The study highlights the key factors influencing the success of assembled building projects in urban renewal, such as stakeholder collaboration, design flexibility, and community engagement. The findings contribute to the growing body of knowledge on urban renewal and sustainable development, providing insights into innovative approaches for preserving cultural heritage while meeting contemporary needs.

Keywords: Assembled Buildings, Industrial Heritage, Adaptive Reuse, Urban Renewal, Sustainable Development.

1. Introduction

The industrial revolution and the elevation of productivity of that period, helped support the economic situation of many working-class families all around the world, especially Britain (Clark, 2014). During this period, a unique architecture pattern was created to support the whole economy utilizing the landscape and living room to create an aesthetic impact. Rapid deindustrialization led to mass abandoned land and buildings after the industrial revolution throughout England, with some areas still awaiting to be reused nowadays (Akansu and Gertik, 2018). These areas in the previous industrial cities have created a unique cultural site which is known as industrial ruination (Mah, 2013).

However, these previous industrial buildings hold valuable cultural heritage assets as people could conduct analysis and feel the industrial age in person. As a result, most of these buildings are simply under protection without any form of renewing and reuse, lowering their economic and practical values day by day. Thus, the society is finding a way to reduce the number of unused industrial buildings and prevent the destruction of these valuable cultural heritage assets would be reusing them for new programs and functions by recycling their usable components (Wong, 2017). This method is called adaptive reuse.

2. Textile Industrial Heritage Building

2.1. Introduction

The Nizhny Tagil Charter for the Industrial Heritage, which establishes the definition of industrial heritage, was introduced in 2003 by the International Association for the Conservation of Industrial Heritage (TICCH). Industrial buildings like spinning and weaving workshops, mills, warehouses, and boiler houses as well as tangible and intangible heritage like places of social activity, production processes, production equipment, data, archives, and other material are all examples of cotton textile industrial heritage, which is one of the parts of industrial heritage and refers to industrial remains of social, historical, and aesthetic value related to the production of the cotton textile industry (Ghanbari, 2018).

The places of activity in the cotton textile industry are mainly cotton mills. Cotton spinning mills in this study are mainly buildings used to describe the various industries associated with cotton production. It covers all the structures manufacturing these fabrics, from spinning processed cotton yarn to weaving, bleaching, dyeing, and printing cotton fabrics (Phelps et al., 2018). It houses the spinning or weaving machinery that produces cotton yarn or fabric. Cotton mills are mainly divided into the multi-story mill and the single-story building (Oevermann, Walczak and Watson, 2022).

Textile industry heritage buildings are distinguished from other heritage buildings mainly because of the textile industry's unique production processes and flow. Different processes require different types of spaces and places. Cotton, the more common natural fibre, accounts for 90% of the natural fibres used in the textile industry. The main processes of the cotton textile manufacturing process are planting and harvesting, preparation processes (cleaning, mixing, pulping, carding), spinning, weaving, finishing, and marketing. The main activity places of the cotton manufacturing process are the blowing room, carding room, spinning room, Weaving shed, etc as shown in Appendix 1.

2.2. Significance

Traditional Textile industrial heritage buildings are significant for a range of reasons. Firstly, they represent a direct link towards the past which could provide us with valuable insight into the social, economic and cultural history of the UK (Landorf, 2009). These buildings were once the centre of the British economy, having a crucial role for being the backbone of the textile industry. By preserving these structures, a connection between the modern-day world and the industrial age through this industrial heritage could be formed for the society to understand the impact of industrialization.

Secondly, textile industrial heritage buildings have

architectural and aesthetic value. They are often characterized by unique design features that reflect the functional requirements of the textile industry (Cossons, 2016). For example, large windows were incorporated into mills to maximize natural light and ventilation, while chimneys were designed to disperse smoke and fumes. These buildings are part of our built heritage and contribute to the visual identity of our cities and towns.

Thirdly, textile industrial heritage buildings have potential for reuse in urban renewal projects. By repurposing these structures, urban areas could be revitalized while preserving cultural heritage (Zhang et al., 2020). Assembled buildings have emerged as a potential solution for adaptive reuse of these historic structures. These modular and adaptable buildings can be customized to meet contemporary needs while respecting the original architectural features of textile mills.

However, preserving textile industrial heritage buildings is not without challenges. Many mills have fallen into disrepair or faced demolition due to economic decline or neglect. More and more cultural heritages around the world are facing problems such as lack of preservation technology and planning to ensure its healthy situation, and higher years of service leading to higher risk of mechanical failure of building materials. Thus, the preservation of these structures requires careful planning, collaboration between stakeholders, and innovative design solutions that balance heritage conservation with contemporary needs.

2.3. Challenges in Preservation

One of the primary challenges in preserving textile industrial heritage buildings is their size. These buildings are often massive structures that require significant resources to maintain and repair. Additionally, their structural complexity can make it difficult to identify areas of weakness or deterioration. With the years in service of the buildings keep growing, the risk of material failure would add up each day for wood and metal erosions which could eventually lead to safety concerns and further damage to the buildings.

Secondly, the changes of land use patterns in nearby areas would be another challenge as many textile mills were built in previous industrial areas which currently could be residential or commercial. This could be challenging as to find economically and environmentally compatible usages for these buildings would be difficult based on their original building style and the supported activities in these buildings under safety restrictions.

Preserving textile industrial heritage buildings requires collaboration between stakeholders, including government agencies, developers, architects, and community members. These groups must work together to identify preservation priorities, secure funding, and develop innovative design solutions that balance heritage conservation with contemporary needs. This could be difficult as bringing all stakeholders together to come up with a resolution would be a long process, while the preservation of heritage sites would be a timely mission. Thus, solutions with lower requirements on worker professionalism and time requirements would be optimal for industrial site reuse projects under these contexts.

2.4. Successful Case Study

Brierfield Mills in Pendle, Lancashire is an excellent case study of the successful reuse of textile industrial heritage buildings in urban renewal projects. The Grade II listed cotton spinning complex was built in 1868 and was purchased by Pendle Council in 2012 with funding from the Homes and Communities Agency (Nevell, 2021). The mill had been closed for some time and was at risk of demolition. However, the council recognized its potential for adaptive reuse and embarked on a £32m redevelopment program.

The regeneration scheme transformed the mill into a mixed-use development that includes apartments, a leisure facility, adult learning center, creative arts studio, and canal marina (Nevell, 2021). The project has created new jobs, stimulated the local economy, and enhanced community well-being. The redevelopment of Brierfield Mills showcases how repurposing industrial buildings can contribute to community development and cultural preservation.

Figure 1. Brierfield Mills, Pendle, Lancashire. Image courtesy of Historic England

The successful reuse of the Brierfield Mills heritage is because of several factors. Firstly, successful collaboration channels between stakeholders, including government agencies, developers, architects, and community members were established and utilized efficiently to ensure the efficiency process of this project. Secondly, innovative design solutions were implemented to increase the potential of the historical sites for contemporary needs. Finally, the project adheres to sustainable development ideas and reducing carbon emissions associated with new construction technologies, causing minimal influences towards the nearby areas to reduce risks of discomfort for the local residents.

In summary, Brierfield Mills is an excellent example of how textile industrial heritage buildings can be successfully repurposed for urban renewal projects. By preserving these historic structures and repurposing them for contemporary needs, we can create vibrant communities that respect our industrial past while embracing our future.

2.5. Conclusion

Textile industrial heritage buildings are valuable assets that can be leveraged to revitalize urban areas while preserving cultural heritage. Their reuse requires a multidisciplinary approach that considers architectural conservation, community engagement, and sustainable design principles. By studying successful case studies and understanding the challenges involved, the full potential of these historical buildings could be unlocked to involve in future building generations.

3. Reuse of Industrial Heritage Buildings

3.1. Background

The reuse of abandoned industrial heritage buildings plays a strategic role in urban renewal, not only affecting buildings but also stimulating a renewal process in large urban areas. Many suburbs that experienced significant development during the Industrial Revolution now face decay, which has become a predominantly social problem. Different types of reuses have different impacts on industrial heritage, and the new uses and scale of change required must be compatible with and appropriate to the historic significance of the site (De Gregorio et al., 2020).

The renovation of former industrial buildings must respect and preserve cultural heritage while addressing aspects of energy saving and comfort necessary today. Abandoned, run-down, and peripheral areas are often more of a social problem than a building problem. Major changes in the production process have led to significant changes in urban planning, opening new opportunities for planners to think about models and mixes of functions while learning from past mistakes.

Urban regeneration presents a challenge that can create new opportunities for communities, resolve critical issues, and test new centralities within the city that are better suited to new jobs and the needs of city dwellers. The renovation of disused industrial areas offers the opportunity to redevelop and transform parts of the city into new functions capable of attracting and virtuously activating a process of renewal. The success of transforming industrial heritage areas lies in finding a balance between historical memory and innovation. Enlightened operators or spontaneous transformations have shown the greatness and potential of these marginal areas. A balance between preserving historical charm and embracing innovation can be the recipe for success.

3.2. Challenges and Opportunities

The renovation of former industrial buildings must respect and preserve cultural heritage while addressing aspects of energy saving and comfort necessary today. Abandoned, run-down, and peripheral areas are often more of a social problem than a building problem. Heritage renewal typically entails the allocation of resources, the closure of transportation system parts, and the demolition of specific districts, which might harm social networks and local character (Yung, Zhang, and Chan, 2017). It has the potential to substantially alter the community's sense of place, identity, and progress. Major changes in the production process have led to significant changes in urban planning, opening up new opportunities for planners to think about models and mixes of functions while learning from past mistakes.

Urban regeneration presents a challenge that can create new opportunities for communities, resolve critical issues, and test new centralities within the city that are better suited to new jobs and the needs of city dwellers. The renovation of disused industrial areas offers the opportunity to redevelop and transform parts of the city into new functions capable of attracting and virtuously activating a process of renewal. Industrial building renovations have been carried out in Russia successfully in the Volga region, which their planning and architectural design composition did not fully meet the requirements of the environment of the neighbourhood as well as the economic background of the city (Gudina and Prokofiev, 2020). Thus, taking a close step towards carrying out redesigning and constructing the industrial heritages could be a huge challenge if design could not meet the overall request of the nearby environment, causing potential financial and societal problems.

3.3. Theoretical Support

(1) Support Housing Theory

The concept of "Support Housing" was proposed by Prof. J.N. Habraken in 1965, which divides residential design and construction into two parts: Support and Detachable Units (John Habraken, 2008).

"Support" is in the public scope of the design decision. It has constituted a building (including but not limited to the structure). Still, it cannot be used as a complete residential function, which restricts the final formation of the living space. "Detachable Units are the redistribution of space within the limits of Support.

From the point of view of industrial, architectural heritage, the building entity loses its original industrial production function. In contrast, the original support structure remains theoretically intact and solid, which limits to a certain extent the living space that will be created, but at the same time provides the basic structure and Support for it. The transformed living space exists as a spatial form that can be accommodated within the spatial constraints of the industrial building. From a conceptual point of view, the distinction between Support and Detachable Units is based on the difference between the decision-makers in the design process, and the core value is to split the process of housing production into two, including the construction of the immutable part of the house in the early stage and the insertion of the variable part in the later stage. From this point of view, transforming an industrial building into a house fits very well with the idea of supportive housing. From this point of view, transforming industrial buildings into houses is very similar to supportive housing.

(2) Shearing Layers Theory

The shear layer is a concept introduced by Frank Duffy, which refers to a building consisting of multiple change layers (Shell, Services, Scenery, Set) (Duffy, 1992). Later Brand modified it slightly by expanding it to six elements: Site, Structure, Skin, Services, Space Plan and Stuff.

Through these six elements reflecting the changes in architecture at different times, scholars study all the possible ways of spatial expression over time through this theoretical area to make corresponding architectural decisions. The site mainly refers to the geography and urban location, which takes the longest time to change, even longer than the survival of generations of buildings. The structure mainly refers to the foundation and load-bearing elements, with a long structural life span ranging from thirty to three hundred years. The skin refers to the exterior surfaces and facades, which are replaced about once every twenty years. The services refer to the working core of the building, including communication lines, fire sprinkler systems, plumbing, HVAC (Heating, Ventilation, Air Conditioning), lifts and escalators, and other moving parts. The service life is about seven to fifteen years. The space Plan mainly refers to the interior layout of a building, including the location of walls, floors, ceilings, and doors. It is replaced more frequently, usually every three years. The stuff mainly refers to furniture, lamps, household items, and decorations. Its replacement time is the most frequent, almost daily to monthly may be updated.

This theory provides a theoretical guide to the subject of

this paper by analysing the various changes in the different layers of the architectural heritage and adapting them more specifically to the new functions of the industrial heritage.

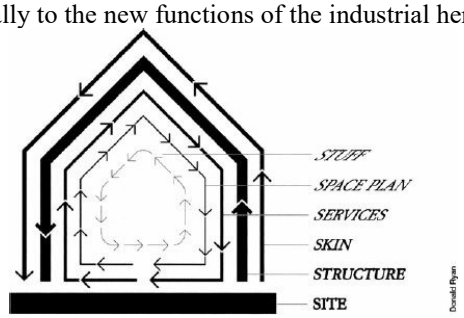

Figure 2. Shearing Layers of Change. Made by Donald Ryan

3.4. Current Status

The concept of reusing industrial heritage buildings is a popular topic among researchers, practitioners, and policy makers around the world. The reuse of industrial heritage buildings is considered to be a viable solution to inject energy to the local economy, revitalize urban areas, preserve cultural heritage, and promote sustainable development. However, challenges also arises along with the recent practices of reuses which are mainly because of solutions lack of innovative technologies and careful plannings to balance the needs of the present and future.

According to Niu et al. (2018), the reuse of industrial heritage buildings involves sustainability issues that go beyond the economic dimension. The authors propose that a sustainable outcome for reusing industrial heritage would require a careful planning process to balance the historical memory and innovation. Using two typical cases carried out in China, the authors revealed that under current contexts, designers and government officials are yet unable to completely consider all aspects of impact by the renewal projects, which would require additional care and considerations. Another article by Grecchi (2022) explores the potential of assembled buildings in the adaptive reuse of industrial heritage buildings. Assembled buildings are modular and adaptable buildings that can be customized to meet contemporary needs while respecting the original architectural features of industrial heritage structures. The article discusses some interesting renovation approaches that also address complex challenges from a sustainability perspective. Another study carried out by Owojori, Okoro and Chileshe (2021) investigates the current status and emerging trends on the adaptive reuse of historic buildings in Europe. The study analyses data from 28 European countries and identifies the main drivers, barriers, and benefits of adaptive reuse projects. The study also provides recommendations for improving policies and practices to foster adaptive reuse as a sustainable strategy for urban regeneration.

These studies are examples of the current focus of research in the domain of reusing industrial heritage, which indicates that innovative and sustainable approaches towards redesigning these buildings are needed for many regions of the world. The reuse of industrial heritage buildings is a complex and multidisciplinary topic that requires collaboration between stakeholders, innovative design solutions, and respect for cultural heritage. Through studying successful cases and understanding the challenges involved in the economic and social sectors, the full potential of these historic structures could be unlocked for our future generations.

4. Case Study Manchester Royal Mills

4.1. Background

Manchester has a long history in the textile industry, which has had a very special and significant impact on British history (Nevell, 2008). At the end of the 18th century, the production of cotton products dominated the textile industry and quickly became the backbone of Manchester's economic development. The development of textile machinery and technological advances led to the rapid expansion of the cotton industry and the construction of many cotton mills, which led to Manchester gaining the title of Cotton City (Nevell, 2008).

Manchester's textile industry began to decline rapidly in the 1920s. In the second half of the twentieth century, several historic cotton mills and textile factories were slowly abandoned due to disrepair and lack of use. These damaged heritage buildings are at increasing risk of demolition. A survey of textile mills in Greater Manchester revealed that approximately 1,158,220 square meters of textile mills were vacant or underutilized, representing approximately 31% of the total floor space of textile mills (Griffiths, Hunt and O'Brien, 1992). Other factories have been inappropriately remodeled, failing to preserve heritage buildings and destroying their historical value. These remaining factories, warehouses, and workshops record Manchester's history and social change. Their character, form, and function reflect technological, economic, and social development. The rate and volume of damage to the textile industry's heritage are significant. An assessment of the survival rate of industrial heritage buildings in Greater Manchester shows that over 50% of heritage buildings have been lost. 20% of surviving factories are considered at significant risk of total loss, and 28% are considered vulnerable to vandalism (Douglas, Hodgson and Lawson, 2002).

Since the end of the twentieth century, there has been an increase in planning guidance for the conservation of historical heritage, and the industrial heritage of many derelict textile mills has been given increasing attention. Some textile mills have been renovated and given new functions and uses. Some have been successfully converted into museums, such as the Helmshore Mills Textile Museum, which was converted from the Helmshore Mill to display wool, cotton, and spinning workshops. Some functions have remained the same and still serve the textile industry, such as Lappet Mill and Britannia Mill, which produce high-quality turbans. However, these are only a small part of the reuse of industrial heritage buildings, and it is essential to find suitable sustainable new uses for the remaining surviving heritage.

4.2. Tangible

The structure, shape, and dimensions of the built heritage significantly impact its adaptive transformation. In the remaining textile industrial heritage, adapting special planning forms and single-story structures such as weaving sheds is more difficult than multi-story rotating buildings and warehouses. This has resulted in many buildings, such as warehouses, being adapted to new functions while weaving sheds have mostly been dismantled. The more successful adaptations of textile industrial heritage have been those based on retaining their particular historic features, including but not limited to form, shape, spatial layout, historical

decoration, and machinery and equipment that once worked for the mill. Of great note is the Watts Warehouse, a Grade II listed building in Manchester city centre.

4.3. Case Analysis

(1) Site

The advantages of site positioning are mainly from three aspects, the historical and cultural value, the strategic and accessible location, and the flexible spacing of the sites. Firstly, a site needs to be in a position where its historical and cultural value could influence people instead of being left alone, meaning that it would need high aesthetic and architectural quality to be an icon or representative of the industrial history and identity of the city or region. The location of the Royal Mill is also part of the urban regeneration and revitalization of the Ancoats district, which was once a thriving industrial area but suffered from decline and decay in the 20th century. The site is one of the industrial heritage reuse projects that helped transform the district into a vibrant and attractive urban neighbourhood. The site also preserves and celebrates the industrial history and identity of the district and the city (Graham Co., 2023).

Another site advantage that can contribute to the successful industrial heritage reuse is the strategic and accessible location of the site. This directly translates into its distance to other urban services and amenities, such as transport, education, health, and other entertainment services. This could increase the potential customer cap of this site which could increase the demand and viability of and around the site for various functions, such as housing, finance, tourism or leisure. The Ancoats district in Manchester is a former industrial area that suffered from decline and decay in the 20th century (Nevell, 2014). The district was regenerated with the help of various industrial heritage reuse projects, such as the Royal Mills site. The district is now a vibrant and attractive urban neighbourhood that offers a range of facilities and opportunities for the local community and visitors.

A third site advantage that can contribute to the successful industrial heritage reuse is the large and flexible space of the site. This is the determinant of the upper potential of a site, as it limits the potential uses and needs to be applied to this area. Larger space could accommodate different uses and needs, which could contribute to the overall happiness of the nearby communities. This could also foster innovation and diversity, as well as social and economic inclusion. The location of the Royal Mill is close to other urban amenities and services, such as transport, education, health, and entertainment. This increases the demand and viability of the site for various functions, such as housing, commerce, tourism, or leisure (Nuran, 2013). The site offers a range of facilities and opportunities for the local community and visitors, such as residential apartments, offices, shops, restaurants, hotels, and a cultural centre.

Figure 3. Near Site of Royal Mill. Photo taken by author

(2) Structure

The Royal Mill's construction is dependable and resilient because it can withstand risks brought both by nature and by people, such as earthquakes, floods, fires, vandalism, or terrorism. This increases the safety and security of the users and occupants while lowering the risk and expense of maintenance and repair. The building also incorporates contemporary architecture and technology while maintaining the mill's unique characteristics and features. The structure of the Royal Mill is also attractive and distinctive, as it enhances the aesthetic and environmental quality of the urban landscape. The structure creates a sense of place and identity, as well as improves the well-being and satisfaction of the users and residents. The structure also showcases the industrial heritage of Manchester and its impact on the world, as well as the latest scientific discoveries and inventions.

Therefore, the structure of the Royal Mill is an important factor that influences the success of its industrial heritage reuse. The structure respects its cultural significance, enhances its economic potential.

Figure 4. The Ceiling Structure of Royal Mill. Photo taken by author

(3) Skin

The exterior appearance of the Royal Mill is attractive and unique, with original features and characteristics of the mill such as the brick walls, arched windows, iron columns, and slate roofs. It successfully blends into the background of the community while the majority of the buildings are in the colour of red. Innovative technologies could also be observed through the exterior appearance, as glass balconies, metal cladding and solar panels could be seen from the outside.

The exterior appearance of the Royal Mill creates a sense of place and identity, as well as improves the well-being and satisfaction of the users and residents. The exterior appearance showcases the industrial heritage of Manchester and its impact on the world, as well as the latest scientific discoveries and inventions. The exterior appearance also reflects the diversity and creativity of the Ancoats district, which is a former industrial area that was regenerated with the help of various industrial heritage reuse projects.

Therefore, the exterior appearance of the Royal Mill is an essential element that determines the effectiveness of its industrial historical reuse. The exterior appearance improves its social and environmental impact.

Figure 5. Exterior Appearance of Royal Mill. Photo taken by author

(4) Services

There are a variety of services available at Royal Mill. The first of all is a 24-hour concierge service which provides additional on-site security and assistance, as well as other amenities such as first aid kits and defibrillators for emergencies. Fire extinguishers and other emergency kits are also available in multiple locations around the site (Certproperty Co., 2023). The site also has two secure gated parking lots for each section, and a front and rear entrance to the buildings.

The services of the Royal Mill also include a large amount of residential and commercial units for the needs and preferences of local residents. The site has a mix of 1-, 2-, and 3-bedroom apartments with the originated interior design to them (Juliet Twist Properties, 2023). The site also incorporates offices, shops, restaurants, hotels, and a cultural centre which could provide the local residents with a variety of options for work, leisure, and entertainment (Certproperty Co., 2023). The services of the Royal Mill also include an impressive glass atrium that has an on-site Ancoats Coffee Company, which is a specialty coffee roaster and cafe that serves high-quality coffee and food. The atrium is a spacious and bright area that creates a welcoming and relaxing atmosphere for the users and residents. The atrium also showcases the industrial heritage of Manchester and its impact on the world, as well as the latest scientific discoveries and inventions (Juliet Twist Properties, 2023). The services of the Royal Mill also include an impressive glass atrium that has an on-site Ancoats Coffee Company, which is a specialty coffee roaster and cafe that serves high-quality coffee and food. The atrium is a spacious and bright area that creates a welcoming and relaxing atmosphere for the users and residents. The atrium also showcases the industrial heritage of Manchester and its impact on the world, as well as the latest scientific discoveries and inventions (Juliet Twist Properties, 2023).

Figure 6. The atrium of Royal Mill. Photo taken by author

(5) Space Plan

The space plan of the Royal Mill is flexible, incorporating multiple services and area designs at the same time including residential areas, office areas, commercial areas and dining facilities, indicating the strong fundamental conditions which contribute to the high potential of accommodations. It is also efficient and functional, as it maximises the use of available space, without sacrificing natural lighting and green spaces for customers for a more comfortable experience. The space plan of the Royal Mill is also attractive and distinctive, as it enhances the aesthetic and environmental quality of the urban landscape. The space plan preserves the original structure and style of the mill, while incorporating contemporary design and technology. The space plan also reflects the diversity and creativity of the Ancoats district, which is a former industrial area that was regenerated with the help of various industrial heritage reuse projects.

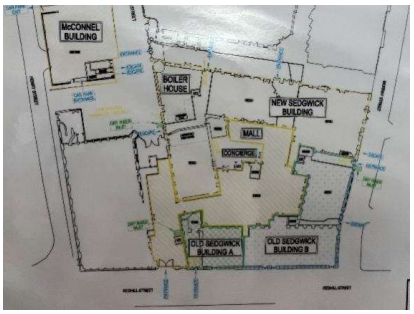

Figure 7. The Royal Mill Space Plan. Photo taken by author

(6) Stuff

The stuff of the Royal Mill is stylish and eclectic, as it combines the original features and character of the mill with contemporary design and technology. The stuff preserves the industrial heritage of Manchester and its impact on the world, as well as reflects the diversity and creativity of the Ancoats district. The stuff also enhances the aesthetic and environmental quality of the urban landscape, as well as improves the well-being and satisfaction of the users and residents.

Some examples of the stuff of the Royal Mill are: The exposed brick walls, arched windows, cast iron columns, and slate roofs that give the building a historic and authentic look. The glass balconies, metal cladding, and solar panels that add a modern and sustainable touch to the building. The atrium has a glass roof, wooden floors, metal beams, and industrial-style lamps that create a welcoming and relaxing atmosphere for the users and residents. The high ceilings, wooden floor and large windows for the apartments. Also with leather sofas, wooden tables, metal chairs, and colourful cushions which also sends a historical feeling.

Figure 8. The Royal Mill Stuff. Photo taken by author

4.4. Intangible

(1) Historical Value

The Royal Mill, as one of the most valuable industrial heritage sites, has a rich history which gives it strong historical and cultural values for the society. The Royal Mill is a former cotton mill that was built in 1912 on part of the site of the earlier McConnel & Kennedy mills, established in 1798. It is one of the last of “an internationally important group of cotton-spinning mills" sited in East Manchester, which collectively comprise “the best and most-complete surviving examples of early large-scale factories concentrated in one area" (Science and Industry Museum, 2023). This could effectively remind people of the strong and deep influences of the industrial revolution, which eventually led to the advanced technological society people live in nowadays.

The Royal Mill was originally called New Old Mill and was renamed following a royal visit by King George VI and Queen Elizabeth in 1942 (Science and Industry Museum, 2023). A plaque commemorates the occasion The Royal Mill is a Grade II* listed building and a symbol of Manchester’s industrial past. The Royal Mill solely by its name could represent the age of kingship of England, which almost occupies the whole British history. The Royal Mill was designed by H.S. Porter of Accrington using Accrington brick and terracotta in the Edwardian Baroque style. It had cast iron columns supporting by transverse steel beams and reinforced concrete floors. It was one of the first generation of mills purpose built for electricity, which was provided by the corporation and a new substation built in 1915 (Science and Industry Museum, 2023). This architecture style could be the marker from steam power to electricity, and could be the connection between the first and second industrial revolution.

The Royal Mill was part of the Fine Cotton Spinners and Doublers Association Ltd, which was formed in 1898 by a merger of several spinning companies, including McConnells. The association was the largest cotton-spinning company in the world, with over 60 mills and 30,000 employees. It produced high-quality cotton yarns for domestic and export markets. This is a marker of the capitalism progression in British history, which could mark the beginning of mass industrialization of the whole world. The Royal Mill is part of the Ancoats district, which was once a thriving industrial area but suffered from decline and decay in the 20th century. The district was regenerated with the help of various industrial heritage reuse projects, such as the Murrays’ Mills site and the Science and Industry Museum. The district is now a vibrant and attractive urban neighbourhood that preserves and celebrates its industrial history and identity (Certproperty Co., 2023). This is an icon of deindustrialisation after the industrial revolution. This happened all around the world, leaving the previous industrial cities with abandoned regions and industrial buildings. Now, the Royal Mill could be a successful example of reusage which could contribute to future projects around the world.

(2) Technical Value

The Royal Mill is one of the first generation of mills purpose built for electricity, which was provided by the corporation and a new substation built in 19151 This means that the mill was designed to house electrically-powered mules, which were machines that spun cotton into yarn. Electrically-powered mules were more efficient, reliable, and safe than steam-powered ones, and could produce finer and higher-quality yarns (Certproperty Co., 2023).

The Royal Mill has a reinforced concrete floor system, which was a novel and innovative feature at the time of its construction. Reinforced concrete floors are stronger, lighter, and more fire-resistant than wooden floors, and can support heavier loads and larger spans. Reinforced concrete floors also reduce the vibration and noise caused by the spinning machines, and improve the thermal and acoustic insulation of the building (Certproperty Co., 2023). The Royal Mill has a transverse steel beam system, which was another advanced and experimental feature at the time of its construction. Transverse steel beams are horizontal beams that span across the width of the building, rather than along its length. Transverse steel beams allow for more flexibility and adaptability in the layout and distribution of the spaces within the building, as well as more natural light and ventilation (Certproperty Co., 2023). Transverse steel beams also reduce the number and size of the columns needed to support the structure, and create a more open and spacious feel. Therefore, the technical values of the Royal Mill demonstrate its cutting-edge and pioneering design and technology, as well as its efficiency and functionality. The technical values also showcase the industrial heritage of Manchester and its impact on the world, as well as the latest scientific discoveries and inventions.

(3) Economic Value

The Royal Mill is a comprehensive functional area with residential areas, office areas, commercial areas, dining facilities and a cultural centre. Other than consumers and spendings, these facilities also create valuable job opportunities for local businesses and residents which contribute to the overall urban economy system (Certproperty Co., 2023). This site also improved the economic system for the Ancoats district, which was an industrial area suffering from decline and decay since the 20th century.

The Royal Mill is a Grade II* listed building and a symbol of Manchester’s industrial past (Certproperty Co., 2023). The site preserves and celebrates the industrial heritage of Manchester and its impact on the world, as well as showcases the latest scientific discoveries and inventions. The site attracts visitors, investors, and developers who are interested in preserving and celebrating the industrial heritage. The site also enhances the cultural identity and image of the city and the district. The site creates value and demand for the historic and architectural quality of the building. The Royal Mill is one of the first generation of mills purpose built for electricity, which was provided by the corporation and a new substation built in 1915 (Certproperty Co., 2023). The site demonstrates its cutting-edge and pioneering design and technology, as well as its efficiency and functionality. The site incorporates contemporary design and technology, such as glass balconies, metal cladding, and solar panels. The site also incorporates environmental sustainability, such as reducing the waste of resources and energy. The site creates value and demand for the innovative and sustainable features of the building (Certproperty Co., 2023). Therefore, the economic values of the Royal Mill demonstrate its potential and impact for the urban development and regeneration, as well as its respect for its cultural significance and features.

4.5. Intangible

The Royal Mill is a successful case of industrial heritage reuse, as it demonstrates how a former cotton mill can be redeveloped and transformed into a mixed-use complex that respects its original values and features, while adapting to modern standards and demands. The site has various advantages that contribute to its success, such as its historical, technical, economic, site, space, skin, and service values. The

site preserves and celebrates the industrial heritage of Manchester and its impact on the world, as well as showcases the latest scientific discoveries and inventions. The site also contributes to the urban regeneration and revitalization of the Ancoats district, which is a former industrial area that was regenerated with the help of various industrial heritage reuse projects. The site also offers a range of facilities and opportunities for the local community and visitors, such as housing, commerce, tourism, or leisure. The site also enhances the cultural identity and image of the city and the district, as well as improves the well-being and satisfaction of the users and residents.

5. Results

5.1. Field Research Results

Through conducting field research about the Manchester Cotton Mill heritages, several sites are collected which are considered as successful reused sites. In this section, each site would be introduced with their current usage, traffic amount, transportation situations and the site characteristics. The sites are as follows in this table:

Table 1. Renovation Project of the Cotton Textile Industrial Heritage. Compiled by Author

Project	Time of renovation	Original condition	Status after Renovation	Photo
Helmshore Mill	1985	Cotton Mill	Textile Museum	
Moor Lane Mill	1988	Cotton Mill	Office Space Student Residence	
Higherford Mill	1999	Spinning Mill	Cultural Heritage Centre Art Gallery Education Resource Centre	
Ilex Mill	2003	Cotton Mill	Apartments Rooftop Penthouses	
Murrays' Mills	2013	Cotton Spinning Factory	Office Space Flats Hotel	
Lomeshaye Bridge Mill	2014	Cotton Spinning Mill	Workspace Archive storage Workshop	
Holmes Mill	2017	Textiles Mill	Beer Hall Bar & Grill Hotel Food Hall	

(1) Helmshore Mill

The Helmshore Mill is currently operating as a textile museum showcasing the history and technology of wool and cotton production in Lancashire. The museum regularly hosts exhibitions and other events for schools and families to increase community values. As the mill is in a rural area, the customer traffic amount is moderate as it is also not easily accessible via public transit. The museum's availability is also limited as it is only available for three days per week between April and November (Council, 2023). Apart from these limitations, its site advantages are also clear and strong. The site has a picturesque rural setting, surrounded by green fields and hills. The site also has a park with picnic tables, benches, and a children's play area. The site offers scenic views of the Rossendale valley and the Pennine hills, which could potentially attract more sightseeing tourists (Council, 2023). The site has a historic and authentic look, with stone-built structures, slate roofs, wooden floors, cast iron columns, brick walls, arched windows, and pitch-back water wheels. The site also has original machinery that dates back to the 18th and 19th centuries, such as carding engines, spinning mules, fulling stocks, and looms. The site also has a plaque that commemorates the royal visit by King George VI and Queen Elizabeth in 1942 (Council, 2023).

(2) Moor Lane Mill

The Moor Lane Mill currently serves as an office complex which holds various businesses and organisations, such as Lancaster City Council, Lancaster University, and Lancashire County Council. The site also has commercial units such as cafe, gym, hair salon, and travel agency. The customer traffic amount of Moor Lane Mill is relatively high, as it is located in a central and accessible location that attracts many visitors and workers. This site is quite close to other amenities of the city such as transportation, education, health services, and entertainment. This site is within walking distance from Lancaster Railway Station, which provides convenient transportation services across the country. This site also serves as a successful case for the adaptive reuse of industrial heritage sites.

(3) Higherford Mill

The Higherford Mill currently serves as an artists' studio and creative industries space for artists and craftsmen, including painting, sculpture, photography, jewellery, and glass (Horsley, 2023). The customer traffic to this site is relatively low, as it is located in a rural area, and it does not obtain a high social and economic value by having commercial units around its site. It is also hard to connect with public transportation, which further reduces its customer traffic. However, this site is unique for its interior design and stuff which shows its authenticity and rich history. The site has a historic and authentic look, with stone-built structures, slate roofs, wooden floors, cast iron columns, brick walls, arched windows, and pitch-back water wheels. The site also has original machinery that dates back to the 18th and 19th centuries, such as carding engines, spinning mules, fulling stocks, and looms (Horsley, 2023). This site is also considered as a successful adaptive reusage of an industrial heritage site.

(4) Ilex Mill

The current usage of Ilex Mill is a residential complex which mainly consists of one and two bedroom luxury apartments. The site also includes leisure facilities such as restaurants, hotels, and a cultural centre. The customer traffic of this site is relatively high, as it is located in a central area with easy access to public transportation and other urban amenities. The site consists of a historic working mill that was built in 1856 by Peter Whitehead in Rawtenstall, Lancashire. The mill was built on the River Irwell, which provided water power for the machinery. The mill reached its peak of production in 1895 when it had 50,000 spindles and 748 looms (Horsley, 2023). This is a marker of the textile industry in the history of Britain which is one of the most valuable factors of this site (Horsley, 2023).

(5) Murray's Mills

Murray's Mills preserves the historical and cultural value

of the world's oldest surviving steam-powered cotton mill, which is a Grade II* listed building and a symbol of Catawba County's industrial past. The mill was built in 1913 by John Murray, who ran it with his three sons until 1967 (Horsley, 2023). The mill produced high-quality cotton yarns for domestic and export markets. It also contributes to the urban regeneration of the Catawba River Valley, which was an industrial area similar to the Ancoats district, which suffered from decline and decay in the 20th century. The site has a relatively high amount of customer traffic because of the commercial facilities it incorporates, such as a museum, cafe, and a park. It also demonstrates innovative design and technologies with the application of natural lighting inside buildings and the solar panels for sustainable development considerations (Horsley, 2023).

(6) Lomeshaye Bridge Mill

Lomeshaye Bridge Mill is a former cotton mill that was built in 1841 on the banks of the Leeds and Liverpool Canal in Nelson, Lancashire. It is one of the oldest surviving steam-powered cotton mills in the world and a Grade II* listed building. The mill was purchased by the Heritage Trust for the North West in 1998, with the support of the Prince of Wales' Regeneration Trust (Horsley, 2023). The mill was redeveloped into a mixed-use complex that includes workspace, archive storage, and a workshop for the Trust's Conservation Services. The mill also offers a museum, a cafe, a shop, and a park for the local community and visitors. The mill hosts various events and activities for the public, such as exhibitions, workshops, demonstrations, tours, and festivals. The mill demonstrates a creative and innovative design-led approach that balances the conservation of the historic fabric of the building with the adaptation to modern standards and demands. The mill incorporates contemporary design and technology, such as glass balconies, metal cladding, and solar panels, while retaining the original features and character of the mill complex, such as steel beams, vaulted ceilings, and original archways (Horsley, 2023).

(7) Holmes Mill

Holmes Mill in Clitheroe, England, is a former cotton mill that was built in 1823 and redeveloped into a brewery, hotel, and entertainment complex in 2015. The site is a Grade II* listed building and a symbol of Lancashire's industrial past. The site also claims to have the longest bar in the United Kingdom, which is 105 feet and 4 inches long. This site is currently serving as a beer hall, restaurant, and a food hall, attracting huge customer traffic each day because of its central positioning and convenient public transportation connectivity. This site also has a large viable room which gave it potential to incorporate multiple services such as office, restaurant, and a culture centre. This is one typical successful case of adaptive reuse of industrial heritage sites.

5.2. Conclusion

From the site studies, it could be concluded that many reuse projects in Manchester have been successfully carried out for their adaptive reuse purposes. Since the objective of adaptive reuse is possible and practical, the improvements on the renewal techniques should be discussed in the following section to discuss its practicability, especially the assembled building technology for the industrial heritage sites.

6. Discussion and Conclusion

6.1. Summary

This study explored the potential of assembled buildings in the adaptive reuse of industrial heritage buildings in the UK. The study employed a mixed-methods approach, involving qualitative and quantitative data collection and analysis. The study used the shearing layers theory, the analytic hierarchy process (AHP), and field research to address the research questions.

The key findings of the study were: Assembled buildings can be effectively integrated into the reuse of industrial heritage in the UK, addressing aspects of economic, social, and environmental sustainability. The key factors influencing the success of assembled building projects in urban renewal are stakeholder collaboration, design flexibility, and community engagement. The reuse of industrial heritage buildings using assembled buildings has positive implications for preserving cultural heritage, stimulating local economies, creating employment opportunities, and enhancing community well-being.

6.2. Interpretations

The results of this study indicate that assembled building technology is a practical and feasible option for the adaptive reuse of industrial heritage sites. Assembled buildings are modular and adaptable buildings that can be customized to meet contemporary needs while respecting the original architectural features of industrial heritage structures. The results show that assembled buildings have several advantages over traditional building methods, such as:

Reduced construction time and cost: Assembled buildings can be prefabricated off-site and assembled on-site, reducing the need for extensive demolition and reconstruction. This can save time and money, as well as minimize disruption to the surrounding environment. Enhanced flexibility and functionality: Assembled buildings can be easily modified, expanded, or relocated to suit changing needs and preferences. This can increase the functionality and usability of industrial heritage sites, as well as extend their lifespan. Improved sustainability and energy efficiency: Assembled buildings can incorporate renewable energy sources, smart technologies, and green materials to reduce carbon emissions and energy consumption. This can contribute to sustainable development and environmental protection. These advantages demonstrate that assembled building technology is a practical and feasible option for the adaptive reuse of industrial heritage sites. By using this technology, historic structures could be effectively revitalized while preserving their cultural significance and without causing major issues.

6.3. Implications

The results of this study have several implications for the field of urban renewal and industrial heritage reuse. By exploring the potential of assembled buildings in the adaptive reuse of industrial heritage buildings, this study offers insights into innovative approaches for preserving cultural heritage while meeting contemporary needs.

Firstly, this study contributes to the growing body of knowledge on urban renewal and sustainable development in the field of architecture. It shows how assembled buildings can be effectively integrated into the reuse of industrial heritage in the UK, addressing aspects of economic, social, and environmental sustainability. It also highlights the key

factors influencing the success of assembled building projects in urban renewal, such as stakeholder collaboration, design flexibility, and community engagement Secondly, this study has practical implications for policymakers, architects, and urban planners involved in urban renewal projects. The findings can inform decision-making processes related to building design, adaptive reuse strategies, and community engagement. The study also provides examples of successful case studies of assembled building projects in the reuse of industrial heritage, such as the Royal Mills and Holmes Hall, which can serve as models or inspirations for future projects. In summary, this study demonstrates that assembled building technology is a practical and feasible option for the adaptive reuse of industrial heritage buildings. By using this technology, we can revitalize these historic structures while preserving their cultural significance.

6.4. Limitations

While a conclusion is derived from this study, there are some limitations which should be acknowledged to be avoided by scholars from future research. These limitations may affect the universality and validity of the findings, but they suggest potential directions of improvement for future research.

Firstly, this study only used a small sample size of one major case study, one minor case study, and seven field studies which could limit the representativeness and diversity of the data, making the results of this study context based which may introduce sampling bias and error. A larger sample would be optimal to increase the reliability and validity of the results. Secondly, only one method of data analysis was used during this research. The study relied on the analytic hierarchy process (AHP) to prioritize and evaluate different factors related to the success of assembled building projects in urban renewal. While AHP is a useful and widely used decision-making tool, it has some drawbacks, such as subjectivity, inconsistency, and sensitivity to changes in criteria or alternatives. Other methods, such as cost-benefit analysis, multi-criteria analysis, or fuzzy logic, could be used to complement or compare with AHP results. Finally, the lack of longitudinal data on the long-term impacts of assembled building projects in urban renewal is present. The study focused on the current status and emerging trends of the reuse of industrial heritage buildings in the UK, but it did not follow up on the outcomes and effects of these projects over time. Longitudinal data would be valuable to assess the sustainability and durability of assembled buildings in the adaptive reuse of industrial heritage buildings.

These are some of the limitations of this study that should be considered when interpreting and applying the findings. Future research could address these limitations by using larger and more diverse samples, employing multiple methods for data analysis, and collecting longitudinal data on the long-term impacts of assembled building projects in urban renewal.

6.5. Recommendations

Based on the findings and implications of this study, the following recommendations are proposed for future research and practices.

Firstly, future research should explore the impact of assembled building projects on long-term sustainability and durability of industrial heritage buildings. This could not be achieved as this technology has not been put in use for a considerable amount of time. This could help assess the environmental and economic impact of this technology, as well as the potential risks and challenges associated with the implementation of this technology. Secondly, scholars should consider using assembled building technology as a viable option for the adaptive reuse of industrial heritage buildings. This technology can offer flexibility, functionality, and sustainability, while preserving the historical and architectural value of these structures. Finally, collaboration between stakeholders is key for adaptive reuse of industrial heritage buildings, to ensure minimal damage and impact would occur to avoid social and economic problems. This could also enhance community engagement and neighbourhood happiness, as well as the ultimate goal of cultural preservation.

These are some of the recommendations that stem from this study. By following these suggestions, the full potential of industrial heritage buildings for urban renewal and sustainable development can be unlocked for the next generations in the future.

Acknowledgments

The authors gratefully acknowledge the faculty and academic support from Manchester School of Architecture.

References

[1] Akansu, V. and Gertik, A. (2018). The sustainability of unused industrial areas: an example, historical development of the Cyprus copper deposit. Amazonia Investiga, 7(14), pp.91–103.

[2] Amir Ali Ghanbari (2018). Industrial Heritage in Historical Urban Landscapes - The Role of Sugar Factory in Urban Landscape of Varamin . DOAJ (DOAJ: Directory of Open Access Journals). doi:https://doi.org/10.22034/manzar.2018.68623.

[3] Certproperty Co. (2023). Royal Mills - One of Manchester's most iconic buildings. [online] CERT Property. Available at: https://certproperty.co.uk/projects/royal-mills/.

[4] Cossons, N. (2016). Why Preserve the Industrial Heritage? Industrial Heritage Re-tooled.

[5] Council, L.C. (2023). Helmshore Mills Textile Museum. [online] Lancashire.gov.uk. Available at: https://www.lancashire.gov.uk/leisure-and-culture/museums/helmshore-mills-textile-museum/ [Accessed 18 Sep. 2023].

[6] De Gregorio, S., De Vita, M., De Berardinis, P., Palmero, L. and Risdonne, A. (2020). Designing the Sustainable Adaptive Reuse of Industrial Heritage to Enhance the Local Context. Sustainability, 12(21), p.9059. doi:https://doi.org/10.3390/su12219059.

[7] Douglas, I., Hodgson, R. and Lawson, N. (2002). Industry, environment and health through 200 years in Manchester. Ecological Economics, [online] 41(2), pp.235–255. doi:https://doi.org/10.1016/s0921-8009(02)00029-0.

[8] Duffy, F. (1992). The changing workplace. London: Phaidon Press.

[9] Graham Co. (2023). Residential Building Project for Murrays' Mill - GRAHAM. [online]

[10] Graham. Available at: https://www.graham.co.uk/projects/building-residential-murrays-mill [Accessed 18 Sep. 2023].

[11] Grecchi, M. (2022). Industrial Heritage: Sustainable Adaptive Reuse. Springer eBooks, pp.53–69. doi:https://doi.org/10.1007/978-3-030-89836-6_4.

[12] Griffiths, T., Hunt, P.A. and O'Brien, P.K. (1992). Inventive Activity in the British Textile Industry, 1700–1800. The Journal of Economic History, 52(4), pp.881–906. doi:https://doi.org/10.1017/s0022050700011943.

[13] Gudina, M. and Prokofiev, E. (2020). The principles of identity in the renovation of industrial buildings in historical cities of Russia. IOP Conference Series: Materials Science and Engineering, 890, p.012015. doi:https://doi.org/10.1088/1757-899x/890/1/012015.

[14] Horsley, N. (2023). Mills Transformed - Higherford Mill. [online] mills-transformed.com. Available at: https://mills-transformed.com/higherford-mill [Accessed 18 Sep. 2023].

[15] John Habraken, N. (2008). Design for flexibility. Building Research & Information, 36(3), pp.290–296. doi:https://doi.org/10.1080/09613210801995882.

[16] Juliet Twist Properties (2023). Royal Mills Manchester. [online] julietwist.co.uk. Available at: https://julietwist.co.uk/developments/ancoats-manchester-2/royal-mills/ [Accessed 13 Oct. 2022].

[17] Landorf, C. (2009). A Framework for Sustainable Heritage Management: A Study of UK Industrial Heritage Sites. International Journal of Heritage Studies, 15(6), pp.494–510. doi:https://doi.org/10.1080/13527250903210795.

[18] Liliane Wong (2017). Adaptive reuse : extending the lives of buildings. Basel: Birkhäuser.

[19] Mah, A. (2013). Industrial ruination, community, and place : landscapes and legacies of urban decline. Toronto: University Of Toronto Press.

[20] Nevell, M. (2008). The Archaeology of Industrialisation and the Textile Industry: the Example of Manchester and the South-western Pennine Uplands During the 18th Century (Part 1). Industrial Archaeology Review, [online] 30(1), pp.33–48. doi:https://doi.org/10.1179/174581908x285110.

[21] Nevell, M. (2014). LEGISLATION AND REALITY: THE ARCHAEOLOGICAL EVIDENCE FOR SANITATION AND HOUSING QUALITY IN URBAN WORKERS' HOUSING IN THE ANCOATS AREA OF MANCHESTER BETWEEN 1800 AND 1950. Industrial Archaeology Review, 36(1), pp.48–74. doi:https://doi.org/10.1179/0309072814z.00000000031.

[22] Nevell, M. (2021). Re-Using Industrial Buildings – Two New Textile Mill Case Studies. [online] Industrial Heritage Networks. Available at: https://industrialheritagenetworks.com/2021/03/12/re-using-industrial-buildings-two-new-textile-mill-case-studies/ [Accessed 18 Sep. 2023].

[23] Niu, S., Lau, S.S.Y., Shen, Z. and Lau, S.S.Y. (2018). Sustainability issues in the industrial heritage adaptive reuse: rethinking culture-led urban regeneration through Chinese case studies. Journal of Housing and the Built Environment, 33(3), pp.501–518. doi:https://doi.org/10.1007/s10901-018-9614-5.

[24] Nuran, M. (2013). Reuse Of Industrial Built Heritage For Residential Purposes In Manchester. METU JOURNAL OF THE FACULTY OF ARCHITECTURE, 30(01). doi:https://doi.org/10.4305/metu.jfa.2013.1.7.

[25] Oevermann, H. and Jones, P. (2021). Experience and Engagement: Good Practice in Heritage Conservation and Adaptive Reuse of Textile Mills in UK and Germany. The Historic Environment: Policy & Practice, pp.1–30. doi:https://doi.org/10.1080/17567505.2021.1970911.

[26] Owojori, O.M., Okoro, C.S. and Chileshe, N. (2021). Current Status and Emerging Trends on the Adaptive Reuse of Buildings: A Bibliometric Analysis. Sustainability, 13(21), p.11646. doi:https://doi.org/10.3390/su132111646.

[27] Phelps, A., Gregory, R., Miller, I. and Wild, C. (2018). The textile mills of Lancashire : the legacy. Lancaster: Oxford Archaeology North.

[28] Science and Industry Museum (2023). The world's first industrial city. [online] Science and Industry Museum. Available at: https://www.scienceandindustrymuseum.org.uk/objects-and-stories/worlds-first-industrial-city.

[29] Yung, E.H.K., Zhang, Q. and Chan, E.H.W. (2017). Underlying social factors for evaluating heritage conservation in urban renewal districts. Habitat International, 66, pp.135–148. doi:https://doi.org/10.1016/j.habitatint.2017.06.004.

[30] Zhang, J., Cenci, J., Becue, V., Koutra, S. and Ioakimidis, C.S. (2020). Recent Evolution of Research on Industrial Heritage in Western Europe and China Based on Bibliometric Analysis. Sustainability, 12(13), p.5348. doi:https://doi.org/10.3390/su12135348.