UTM UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 10(2)/2023, 25-37

Sustainable Adaptive Reuse Strategy Evaluation for Cultural Heritage Buildings

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ABSTRACT

Historical buildings are heritages that play a strategic role in the sustainable building environment need to be protected, and the continuation of the building stock from the past to the present should be ensured. With the concept of adaptive reuse, it is important that historical buildings gain new functional features with contemporary additions, ensure the continuity of cultures and carry the traces of the past to future generations. The aim of this study is to determine the adaptive reuse strategy of historic buildings, and to observe how contemporary additions are integrated to maintain a sustainable form of conservation. The research question of th study is how the contemporary additions that can meet the needs of the reuse of the historical buildings are applied. The building samples obtained through the literature review were evaluated in terms of physical aspects include criteria such as the size and mass of the additions, material selection, and the suitability of the existing historical building to the new function by using the comparative analysis method. It has been determined that although the designs of the additions are different from each other, most of the additions to the existing buildings are made for commercial and cultural purposes and involve steel and glass materials. The built environment can be revitalized as a result of bringing these buildings to society, using new functions and contemporary materials, and introducing economic, socio-cultural, and environmental innovations.

Article History

Received : *12 September 2022*
Received in revised form : *16 December 2022*
Accepted : *28 December 2022*
Published Online : *30 April 2023*

Keywords:

Adaptive reuse, Contemporary addition, Historical building heritage, Innovative building material, Sustainability

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DOI: 10.11113/ ijbes. v10.n2.1060

1. Introduction

The concept of conservation is a multidimensional phenomenon that includes many components, and one of the most important features of conservation is keeping the historical environments alive with the values they carry. Although traditional methods are used as a protection method, adaptive reuse methods, which are differentiated by the developing material science and the desire for differentiation in design, are widely preferred. Adaptive reuse is a regulation that extends the life of buildings by enabling the use of existing buildings for different functional purposes (Mahtab-uz-Zaman, 2011). Many studies reveal that the adaptive reuse strategy is more sustainable based on economic, social, and environmental impacts compared to the typical demolition of buildings (Aigwi et al., 2022; Chan et al., 2020). One of the reusing an existing building instead of construction a new building, reduces material use, transportation cost, energy consumption, and environmental pollution. Thus, a significant contribution can be made to low carbon consumption and sustainability in nature (Toprak and Sahil, 2021). Since historical buildings were constructed with the conditions and techniques of

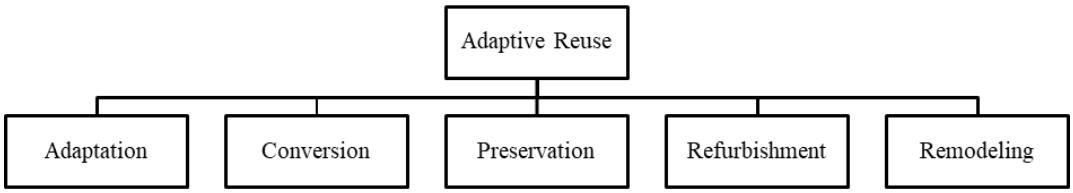
the past, adaptation processes require various levels of intervention (Kutlu et al., 2022).

The adaptive reuse approach focuses on changing the useful and valuable features of the building with contemporary additions using different functions and materials (Shehata et al., 2015). From an economic point of view, it is often cheaper and faster to redevelop historic buildings with adaptive reuse rather than demolishing and rebuilding (Aigwi et al., 2018). In this case, which saves time, financial and structural costs are also reduced (Langston and Shen, 2007). With the re-functioning process for historical buildings, it is ensured that modern design requirements are added and the old building elements are preserved (Aigwi et al., 2020; Yuceer and Vehbi, 2014). Maintaining the existing building's structure and original features (Love and Bullen, 2009) or increasing the functionality of the historical building is one of the main purposes (Wong, 2016). The characteristics of cultures play a role in the change of architectural values (Suprapti et al., 2022; Rahmatulloh et al., 2020).

It is necessary for designers to create specific methodologies, risk management, and measures for adaptive reuse strategy, which has different challenges (Tam et al., 2016). The reuse of culturally valuable buildings in the city requires interdisciplinary thinking. Thus, it is possible to make evaluations where versatile solutions can be found against multi-faceted problems (Foster, 2020; Tafahomi and Nadi, 2020). Application of modern construction techniques instead of old construction techniques in versatile evaluation criteria (Kibert, 2007), the change of a certain part of the building rather than the transformation of the whole (Sandin et al., 2014), understanding its value in the building stock by obtaining realistic databases about the existing building with Building Information Modeling (BIM) technologies (Mustafa et al., 2019; Stephan and Athanassiadis, 2017) are essential and it should be considered to construct economically improving systems by observing the environmental effects of adaptive transformation with technological tools (Shindell, 2015).

Evaluation of cultural heritage buildings in the context of adaptive reuse is a complex process as it must be done without damaging the existing structure, and it is becoming increasingly popular because it is an important subject (Camocini and Nosova, 2017). Douglas (2006) defined this concept as any intervention in a building that goes beyond maintenance to alter its capacity, function or performance. Schmidt et al. (2009) described the adaptive reuse strategy as the reflection of a building and its ability to maximize life value by responding to the needs of the users. Plevoets and Van Cleempoel (2011) explained the adaptive reuse phenomenon as the most effective way of preserving historical buildings and transferring them to future generations. Tanaç Zeren (2013) explained her adaptive reuse strategy as the act of finding a new use for historic buildings that help define the character of societies. Elsorady (2014) defined the concept as renovating historical buildings in a way that allows contemporary activities, without harming the collective memory of the society and the original texture of the building. Tan et al. (2014) emphasized the adaptive reuse approach, the change and transformation of the building by preserving its basic structure and texture. Fiorani et al. (2017) explained the definition of adaptive reuse as a process related to the relations between orientations and spaces in addition to function change. Rodrigues and Freire (2017) defined the concept of adaptive reuse as the retrofitting process of old buildings for new uses. Depending on the definitions made, the terms associated with the adaptive reuse approach are given in Table 1.

Table 1 Concepts associated with the adaptive reuse strategy (by the authors)



Conejos et al. (2016) proposed the principles regarding the building adaptation project in the decision processes in the building where adaptive reuse is applied. Yung and Chan (2012) interviewed practitioners involved in adaptive reuse projects in Hong Kong and explored sustainability factors. In this aspect, technological developments also play a role in decision processes in the adaptive reuse strategy, allowing quick decisions to be made. Multi-criteria techniques such as the space syntax method are used in facades and spatial organizations (Zaleckis et al., 2022; Rao et al., 2022).

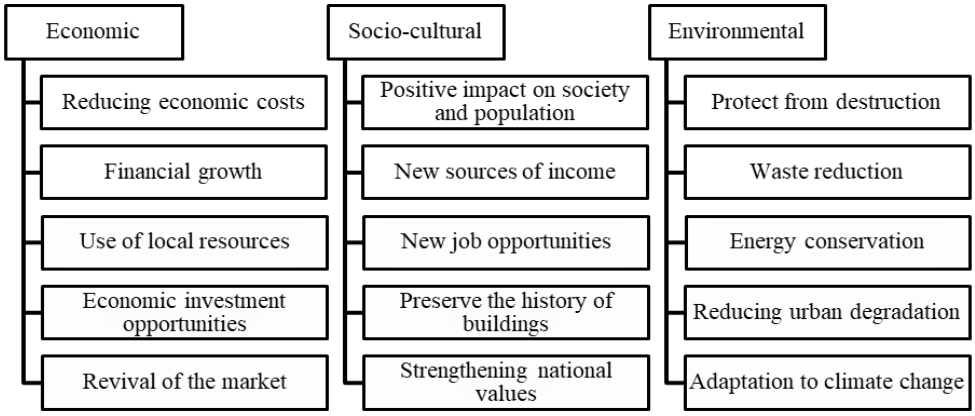
It is also important to identify the actors according to the content of the project and their future use, analysis of the needs of the existing texture and region, classification of emergency and protection measures, proposals for replanning and new additions, and evaluation of adaptive reuse potentials (Mısırlısoy and Günçe, 2016). Adaptation criteria need to be met in the perspective of the symbolic value of the building and new potentials (Bottero et al., 2019). It also affects the circular city strategy in the field of sustainable development of unused or abandoned cultural heritages and rapid transformation of cities takes place (Della Spina, 2021; Clarke et al., 2020). Numerous factors should be considered for the most suitable solution among the different reuse suggestions. A sustainable reuse proposal should transfer the value of historical buildings to future generations, enrich the local culture and raise the economic level of the society. When evaluating the success of an adaptable reuse project; it is expected to offer a physical benefit to the building (Knoth et al., 2022).

In this study, the samples that were re-functionalized to add to the existing building stock by renewing the historical and cultural heritages with contemporary constructions and materials examined. After the literature review, the features of the concept of adaptive reuse were introduced, then inferences were made by making evaluations according to certain parameters in the building, depending on the material and method. In introduction part, information about adaptive reuse is given and literature studies are searched. In Section 2, researches in the architectural context are included by looking at the economic, socio-cultural and environmental aspects, which are the 3 important elements of the adaptive reuse strategy. In Section 3, the characteristics of sustainable building projects are introduced and comparative analyses are made. In Section 4, the information obtained as a result of the comparative analyses has been evaluated. In Section 5, a reference has been made for future work on the building stock, depending on the evaluations made.

2. Adaptive Reuse Features

Adaptive use of buildings is a concept associated with architecture, but with its new function, it also affects various disciplines such as civil engineering, urban planning and politics. From an architectural point of view, the adaptive reuse strategy is linked to deconstruction and material reuse (Chan et al., 2020). It can be defined in three general stages as deconstruction, soft stripping, complete structural disassembly and an individual disassembly project (Chini and Bruening, 2003). Deconstruction approach has two methods as destructive and non-destructive (Smith and Hung, 2015). The purpose of deconstruction is to take raw material from the physical infrastructure for reuse and recycling (Ilerisoy and Takva, 2017; Langston et al., 2008). The term material reuse includes component reuse and recycling (Chan et al., 2020). These concepts, which stand out in the adaptive reuse strategy, require the adoption of different approaches in different building types in terms of economic, socio-cultural and environmental aspects. Table 2 shows the multiple advantages of the adaptive reuse strategy based on sustainability principles.

Table 2 The basic components of the concept of sustainability (by the authors)



New needs should be made in a contemporary language without degrading the original value of historical buildings, so as not to cause any confusion (Tabak and Sirel, 2022). Plevoets and Cleempoel argue that "adaptive reuse" have been started to use more frequently in the sense of urban, architectural and conservation strategy and sustainability of the biggest reasons for this. Concept of sustainability refuses the big scale demolitions and seeks the solution to guarantee ecological and socio-cultural pattern for the sake of future in transformation (Plevoets and Cleempoel, 2019).

In addition, the structural complexity of historic building projects, the environmental costs of demolition waste (Yuan et al., 2011) and regulatory requirements lead to indirect costs in the adaptation process (Wilkinson et al., 2009). In the context of socioeconomic developments, it is important to apply sustainable concepts (Niemczewska, 2020). From a socio-cultural point of view, the development of practical sustainable concepts for urban transformation planning plays a role in the protection of architectural heritage together with adaptive reuse (Alpopi and Manole, 2013). For this reason, the new use of the buildings ensures that the historical heritages that are inactive socio-culturally are brought to the society by reviving them (Esther Yakubu et al., 2017). Environmentally, adapting historical buildings to new uses supports the reduction of pollution (carbon dioxide emission) and energy consumption resulting from construction activities (Itard and Klunder, 2007). Environmental performances of the building such as indoor air quality, acoustic and thermal analysis may not be fully met in some cases, but social gains balance this situation (Chan et al., 2020). Innovative technologies applied in buildings within the scope of adaptive reuse, as passive environmental systems are not generally supported in historical buildings, bring sustainable solutions (Bullen, 2007). Thus, the life cycle of the building is also extended (Othman and Heba, 2018).

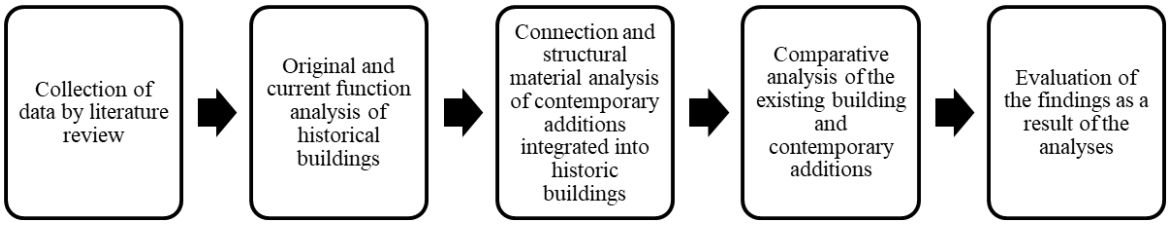
Adaptive reuse projects of historical heritage are a conservation method and approach to maintain the building values and prevent them from falling into ruin (Ali et al., 2018). These projects prevent the uncontrolled demolition of the building, balance the maintenance time and have a positive effect on urban construction by reducing land use (Abdulameer and Sati'Abbas, 2020). Historical streets also connect the community in terms of land use (Zahid and Misirlisoy, 2021). Adaptive reuse projects, which strengthen the bond between societies, provide modern needs and activities by ensuring that buildings reach future generations. Economically, the reuse of historical heritage buildings creates new opportunities in the fields of accommodation, commercial and cultural activities. These projects, which are also important from an aesthetic point of view, increase the demand for buildings in the residential area (Alhojaly et al., 2022). With adaptive reuse strategies against climate change, supportive designs such as improving energy efficiency and making plans for maintenance-related climate change adaptation can be created (Sesana et al., 2018). In addition, analyses can be made depending on greenhouse gas emissions, fossil fuel, and water consumption (Assefa and Ambler, 2017).

Contemporary use of immovable heritage aims to develop by considering sustainable development for both designers, engineers and institutions, but developing a strategy without damaging immovable historical building heritage is a challenging process. It is necessary to draw a road map by taking into account sensitive building elements in buildings that have a social, political, or religious meaning as well as a symbolic value (Lo Faro and Miceli, 2019). Compliance with building codes, conservation laws, temporary supports to stabilize building elements, plumbing and HVAC systems, foundation and roof mechanisms, and space access are criteria that require detail and expertise in adaptive reuse projects (Hein and Houck, 2008). Building codes and regulations/legal restrictions, high redevelopment costs and construction delays, physical constraints, complexity and technical difficulties, inaccuracy of information and drawings, lack of qualified personnel, stability of production and development criteria, commercial risks, uncertainties, and management problems negatively affect the reuse of the building (Eray et al., 2019). In order to avoid making dangerous choices due to the wrong and risky use of resources, resources should be optimized and focused on getting the maximum benefit from society (Dell'Ovo et al., 2021).

3. Methodology

In the adaptive reuse strategy, contemporary additions should be applied without disturbing the texture and structure of historical buildings. From an architectural point of view, the combination of innovative materials and decisions for design and aesthetics brings sustainable solutions. The research question of the study is how the contemporary additions that can meet the needs of the historical building are applied in the most common historical buildings in the literature, which materials are used in terms of structure, and how the combination of old-new harmony is created. In the context of multiple evaluation criteria, the shape and plan geometry, contemporary addition size, contemporary addition material, facade features, function change, symmetry and proportion/size compliance were taken into account in ensuring the old-new harmony (Bottero et al., 2019; Wong, 2016; Conejos et al., 2013). Data were collected through literature review and these parameters were evaluated using comparative analysis. The flow chart of the study is given in Table 3.

Table 3 Flow chart of the study (by the authors)



In this study, historical buildings with high historical value and symbols of countries were selected. Additionally, historical buildings where adaptive reuse strategy is applied with contemporary additions constitute the scope of the study. These buildings were actively used in the period they were built and today they are adapted to meet the usage needs and constitute sustainable building stocks. They are the most known and iconic structures that can be found in the academic literature. With the implementation of the adaptive reuse strategy, the addition of innovative materials contributed to sustainability.

The buildings examined according to the information obtained from the literature review were built between the 15th and the 20th century (Table 4). Six of the buildings are located in the United Kingdom (UK), five in Germany, three in the United States (USA) and others in different countries.

Table 4 Buildings with historical and cultural value where the adaptive reuse strategy is applied (Soliman and Aggour, 2018; Fisher-Gewirtzman, 2016; Fiedler and Schuster, 2016; Mısırlısoy, 2011)

No	Project	Year of Construction	Year of Transformation	City	Country
1	German Parliament Building	1894	1999	Berlin	Germany
2	Jewish Museum	1933	1999	Berlin	Germany
3	Great Court at the British Museum	1820-1850	2000	London	UK
4	Documentation Center Nazi Party Rally Grounds	1930s	2002	Nuremberg	Germany
5	Higgins Hall, Pratt Institute	1869	2005	Brooklyn	USA
6	Gemini Residence	1909	2005	Copenhagen	Denmark
7	The Hearst Tower	1928	2006	New York	USA
8	Caixa Forum	1899	2007	Madrid	Spain
9	Moritzburg Museum	1400s	2008	Halle	Germany
10	Rotermann Carpenter's Workshop	1904	2009	Tallinn	Estonia
11	Rotermann's old and new flour storage	1904	2009	Tallinn	Estonia
12	Museum Der Kulturen	1849	2010	Basel	Switzerland
13	National Maritime Museum	1656	2011	Amsterdam	Netherlands
14	Louviers Music School Rehabilitation and Extension	1659	2012	Louviers	France
15	192 Shoreham Street	Victorian age	2012	Sheffield	UK
16	Museum de Fundatie	1938	2013	Zwolle	Netherlands
17	Bombay Sapphire Distillery	1724-1990	2014	Laverstoke	UK
18	CRICOTEKA Museum of Tadeusz Kantor	1900s	2014	Krakow	Poland
19	Seona Reid Building	1909	2014	Glasgow	UK
20	London Water Tower House	1867	2015	London	UK
21	Elbphilharmonie	1875	2016	Hamburg	Germany
22	Antwerp Port House	1990s	2016	Antwerp	Belgium
23	Tate Modern	1947-1963	2016	London	UK
24	Zeitz MOCAA	1921	2017	Cape Town	South Africa
25	44 Union Square	1928	2020	New York	USA
26	Convent Saint François	1480	2021	Sainte Lucie de Tallano	France

The examined buildings were numbered and classified according to the first year of construction and the year of transformation as a result of the adaptive reuse strategy and are shown in Table 4, in which the buildings are listed chronologically according to the year of transformation. Contemporary approaches, technology opportunities, expanding material range, and the desire for differentiation in design have led to different applications in historical buildings. The current state of the buildings is given in Table 5 according to their functions and the added innovative material properties.

Table 5 Changing features of adaptive reuse projects (Alshawaaf and Lee, 2021; Pieczka and Wowrzeczka, 2021; Takva and İlerisoy, 2021; Šijakovic and Peric, 2018; Kim, 2018)

No	Original function	Current function	Material of the added structure
1	Parliament Building	Parliament Building	Steel frame, clear glazing dome
2	Courthouse	Museum	Steel and reinforced concrete, glass
3	Museum	Museum, library	Steel frame, triangle freeform glass structure consisting of panels
4	Nazi Rally building (meeting place)	Documentation Center	Steel frame and glass
5	Education (academic)	School of Architecture in Pratt Institute	Channel-glass, six pre-cast concrete columns, thick steel beams
6	Frosilos seed silos	Housing	Concrete core mass, glass facade, and glass roof
7	Mixed-use (Office etc.)	Hearst corporation headquarters (office)	Recycled steel, glass facade
8	Power station	Contemporary art museum,	Three main concrete cores, with oxidized cast-iron steel plates

		cultural center	cladding
9	Castle	Art museum	Steel structure and cladding, glass facade
10	Carpentry workshops	Office, commercial	Reinforced concrete core mass, steel frame and glass
11	Industrial building (flour storage)	Office, commercial, storage	Steel constructed glass bridges, cor-ten coating
12	Museum	Ethnographic museum	10,000 three-dimensional, hexagonal glazed ceramic tiles, steel frame
13	Maritime warehouse	Museum	Steel frame and glass roof
14	Ancient monastery	Music school	Precast concrete panel walls, laminated glass, stainless steel
15	Factory	Mixed-use (restaurant and studio office)	Natural wood and plasterboard walls, lightweight steel frame with composite slabs
16	Courthouse	Art museum	8 steel column structure, three-dimensional ceramic facade cladding
17	Corn mill building	Distillation Center	Two new glasshouses
18	Power station	Modern art gallery, museum	Steel truss frame, reinforced concrete core, glass facade
19	Art School	Glasgow School of Art	Translucent glass envelope and concrete structure
20	Water tower	Housing	A new elevator, glass-fronted cube, cast-iron structure
21	Warehouse (cocoa, tobacco, and tea etc.)	Cultural center	Wavy glass mass consisting of panels, steel structure
22	Fire station	Headquarter of port	Three sculptured concrete pillars, triangular glazed surface
23	Power station	Contemporary art museum	Glass beam placed on the roof, steel truss structure
24	Grain silo complex	Contemporary art museum	Three-dimensional glass facade, concrete structure, steel stairs
25	Tammany hall headquarters, performing arts hall	Commercial use	Steel frame, glass dome
26	Castle, monastery	Monastery	A hollow copper structure

Historical buildings, which are an important part of urban systems, shape the use of the region at the city level by creating an environmental impact in terms of their functions (Wang and Liu, 2021). Renewal of the building function is a criterion for achieving the purpose of conservation apart from the main purpose in the adaptive reuse strategy, considering it as a cultural action as well as technical competence (Semprini et al., 2017). In the study, the renovation of new functions to the existing use of the building makes the building more attractive and more visited. The need for new functions in buildings to meet the physical capacity and the provision of mechanical and technical conditions in line with this need play a role in the longevity of the structure (Hong and Chen, 2017). The presence of buildings with commercial and cultural functions, especially in metropolises, has also been reflected in new functions in the buildings after the adaptive reuse strategy (Wang and Nan, 2007). The old and new functions of the historical buildings examined are given in Table 6.

Table 6 Original and new uses of the studied buildings (by the authors)

Project no	Original function								Current function							
	Public	Residential	Educational	Commercial	Religious	Industrial	Military	Cultural	Public	Residential	Educational	Commercial	Religious	Industrial	Military	Cultural
1	■								■							
2	■															■
3								■								■
4	■															■
5			■								■					
6						■				■						
7				■								■				
8						■										■
9							■									■
10				■								■				
11				■		■						■		■		
12								■								■
13				■		■										■

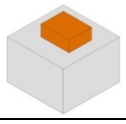
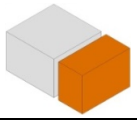
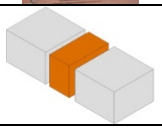
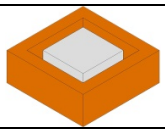
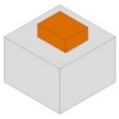
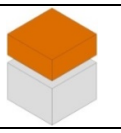
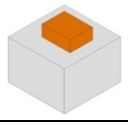
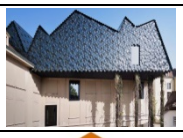
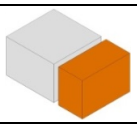
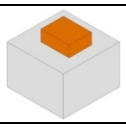
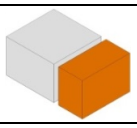
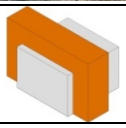
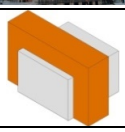
14					■						■					
15				■		■						■				
16	■															■
17				■		■						■		■		
18						■										■
19			■								■					
20						■				■						
21				■		■										■
22	■											■				
23						■										■
24						■										■
25				■				■				■				
26					■		■						■			

Since the re-using building requires more space and different spatial qualities, the transformation must be solved with a different addition from the old structure (Ilerisoy and Soyluk, 2013). In this case, the designer should prevent the planned new addition building from competing with the historic building. In order to prolong the life of the building, the existing building components must be preserved and integrated into the contemporary construction according to the new function (Gusmerotti et al., 2019). In order to reduce design constraints caused by material changes, it is important to apply design and process standardization and monitor the compatibility of existing and new materials (Anastasiades et al., 2021). Analyses should be made by looking at the physical properties, protection status, and technical performance of the existing building material (Addis, 2012). The reuse of materials and the integration of contemporary building materials in an abandoned historical building with the potential for re-functioning should be arranged considering the function of the spaces (Monsù Scolaro and De Medici, 2021). Table 7 shows the use of contemporary and innovative materials added to the structures. In Table 8, the location of the contemporary constructions added to the historical buildings is given.

Table 7 Innovative material properties of regenerated structures as a result of adaptive reuse (by the authors)

Project no	Wood	Reinforced concrete (RC)	Copper	Steel	Composite	Glass	Ceramic
1				■		■	
2		■		■		■	
3				■		■	
4				■		■	
5		■		■		■	
6		■				■	
7				■		■	
8		■		■			
9				■		■	
10		■		■		■	
11				■		■	
12				■			■
13				■		■	
14		■		■		■	
15	■			■	■	■	
16				■		■	■
17				■		■	
18		■		■		■	
19		■				■	
20				■		■	
21				■		■	
22		■		■		■	
23				■		■	
24		■		■		■	
25				■		■	
26			■				

Table 8 Integration of contemporary additions to selected historical buildings (by the authors)

Project no	1	2	3	4	5
Project image					
Structural addition					
Project no	6	7	8	9	10
Project image					
Structural addition					
Project no	11	12	13	14	15
Project image					
Structural addition					
Project no	16	17	18	19	20
Project image					
Structural addition					
Project no	21	22	23	24	25
Project image					
Structural addition					
Project no	26				
Project image					
Structural addition					

In the adaptive reuse strategy, there are four different methods in which the exterior of the building is renewed and the interior spaces are protected, the interior spaces are renewed and the exterior is preserved, the additions shaped according to the needs of the users are made in the existing structure, and only certain parts of the interior are renewed (Tam and Hao, 2019). Architectural design plans can also be changed according to these methods. It is important to develop a reuse concept in line with the principle of sustainability. Adaptable reuse and transformation of existing buildings as a task within the architectural discipline reaches effective solutions with minimum physical interventions, efficient management of existing building materials, and environmentally friendly design of building components in accordance with the principle of efficiency of resources in the context of sustainability, as well as interior architectural design (Celadyn, 2019). While making design plans in architectural design systematics, insertion, intervention, or installation processes are also required (Brooker and Stone, 2019). In these design plans, it is necessary to be aware of the changes and transformations that occur in historical cycles and to develop appropriate legal and design methods. In Table 9, a comparative analysis of the buildings examined according to their architectural design features has been made. The decisions taken during the design process should not cause permanent damage to the building and should increase the value of the historical building in line with sustainability. The criteria in the table are an indication of the direction of the basic architectural approaches in the adaptive reuse phase.

Table 9 Comparison of structures based on architectural criteria (by the authors)

Project no	Shape and plan geometry change	Width change of added structure	Structural material change	Facade material change	Facade colour change	Facade texture change	Function change	Symmetry	Proportion/size compliance
1	■	■	■	■	■	■			
2	■	■	■	■	■	■	■		
3	■		■						■
4	■	■	■	■	■	■	■		
5			■	■	■	■		■	■
6	■	■		■	■	■	■	■	■
7	■	■	■	■	■	■			
8			■	■	■	■	■	■	■
9			■	■	■	■	■		
10	■	■	■	■	■	■			
11			■	■	■	■		■	■
12	■	■	■	■	■	■			
13			■				■		
14			■	■	■	■	■		■
15			■	■	■	■	■		■
16	■	■	■	■	■	■	■		
17	■	■	■	■	■	■			
18	■	■	■	■	■	■	■		
19	■	■	■	■	■	■			
20			■	■	■	■	■		
21			■	■	■	■	■		
22	■	■	■	■	■	■	■		
23		■	■	■	■	■	■		
24			■	■	■	■	■	■	■
25	■		■				■		
26			■	■	■	■	■	■	■

4. Findings

During the examination of the buildings' function change, which are listed chronologically, it can be said that the historical buildings were built mainly with commercial and industrial functions, and after the transformation, the industrial use decreased and the density in commercial and cultural functions increased. When looking at innovative building materials as a result of the adaptive reuse strategy, it has been observed that the constructions are predominantly made of steel and glass materials, and in addition to this, reinforced concrete building materials are also used in buildings at an average level. Apart from this, wood, copper, composite, and ceramic construction materials are rarely preferred. The integration of contemporary

additions to the existing structure is generally positioned on the building mass. Formations in the form of a new structure or a top cover are seen on the existing structure.

In the context of architectural criteria, it was determined that the shape and plan geometry and the width of the added structure changed in approximately half of the buildings, the structure and facade materials changed in almost all buildings, and there were functional changes. In addition to these, it was determined that the symmetry is generally not preserved between the existing and contemporary buildings, asymmetry is more common, and structures with similar features in terms of ratio/size are less common. When considered typologically in general terms, it has been determined that construction systems designed with different shapes and geometries, built with steel and glass building materials for commercial and cultural purposes, located on the historical building are preferred in the context of adaptive reuse.

Considering the information obtained from the literature, academic studies in which the adaptive reuse strategy is applied are examined together, the function, the structural features of the contemporary additions, material and form configurations are examined with comparative analyses are limited. The detailed analysis of the functional and mass changes of historical buildings with the comparative analysis technique is an archive and can be seen as a contribution to the discipline of architectural preservation. The difference of the study from other studies in the literature is that historical building heritages are analyzed in detail with the content analysis method. The scale of the building stock in which the adaptive reuse strategy can be applied is wide. However, the important symbols of the countries with high historical value were examined. In this aspect, the limitation of this study has been drawn.

5. Conclusion

Adaptive reuse projects, where traditional and modern construction systems meet at the same point, form a bridge between the past and the future. In these projects, where traditional construction techniques and building materials are combined with modern and contemporary construction techniques and building materials, long-lasting structures are obtained within the framework of the sustainability principle. The return to active use of abandoned historical buildings, which have symbolic, cultural, religious, social, economic, environmental, and socioeconomic values in terms of architecture, by preserving their architectural and structural features, ensures that the region and the people of the region become active. Considering that demolition and rebuilding of buildings is more costly and in terms of sustainability, the adaptive reuse strategy is seen as an important and advantageous method in terms of maintaining the integrity of the city. In this study, the architectural features of the historical buildings in which the adaptive reuse strategy was applied were determined and analyzed. The importance of the study is to bring together adaptive reuse projects of important historical buildings selected from different countries, to analyze and compare their architectural and structural features in the context of sustainable conservation aspect. Findings on which architectural features are taken into account in adaptive reuse projects have been obtained. By increasing the use of innovative sustainable materials in buildings, it is ensured that they are long-lasting. The continuation of the use of historical buildings at strategic points prevents the disruption of order by maintaining the balance of the city and the region. In a sustainable environment, adaptive reuse strategies are evaluated specifically for the building and passed on to future generations, which also plays an important role in the development of the building stock. Considering the adaptive reuse strategies with this study, the application of contemporary additions will constitute a guiding reference for designers and researchers in the context of its relationship with historical buildings. Based on this study, it is thought that analysis methods will be developed in adaptive reuse projects for future studies.

Acknowledgements

The authors would like to thank Gazi University Academic Writing Application and Research Center for proofreading the article.

References

Abdulameer, Z. A. & Sati'Abbas, S. (2020). *Adaptive reuse as an approach to sustainability*. Paper presented at the 3rd International Conference on Sustainable Engineering Techniques (ICSET 2020), Baghdad, Iraq, 15 April.

Addis, B. (2012). Building with reclaimed components and materials: a design handbook for reuse and recycling. Routledge, London, UK.

Aigwi, I. E., Egbelakin, T. & Ingham, J. (2018). Efficacy of adaptive reuse for the redevelopment of underutilised historical buildings: Towards the regeneration of New Zealand's provincial town centres. *International journal of building pathology and adaptation*, 36(4): 385-407.

Aigwi, I.E., Nwadike, A.N., Le, A.T.H., Rotimi, F.E., Sorrell, T., Jafarzadeh, R. & Rotimi, J. (2022). Prioritising optimal underutilised historical buildings for adaptive reuse: a performance-based MCDA framework validation in Auckland, New Zealand. *Smart and Sustainable Built Environment*, 11(2): 181-204.

Aigwi, I. E., Ingham, J., Phipps, R. & Filippova, O. (2020). Identifying parameters for a performance-based framework: Towards prioritising underutilised historical buildings for adaptive reuse in New Zealand. *Cities*, 102: 102756.

Alhojaly, R. A., Alawad, A. A. & Ghabra, N. A. (2022). A Proposed Model of Assessing the Adaptive Reuse of Heritage Buildings in Historic Jeddah. *Buildings*, 12(4): 406.

Ali, Z. M., Zawawi, R., Myeda, N. E. & Mohamad, N. (2018). Adaptive reuse of historical buildings: Service quality measurement of Kuala Lumpur museums. *International Journal of Building Pathology and Adaptation*, 37(1): 54-68.

Alpopi, C. & Manole, C. (2013). Integrated urban regeneration–solution for cities revitalize. *Procedia Economics and Finance*, 6: 178-185.

Alshawaaf, N. & Lee, S. H. (2021). Business model innovation through digitisation in social purpose organisations: A comparative analysis of

Tate Modern and Pompidou Centre. *Journal of Business Research*, 125: 597-608.

Anastasiades, K., Goffin, J., Rinke, M., Buyle, M., Audenaert, A. & Blom, J. (2021). Standardisation: An essential enabler for the circular reuse of construction components? A trajectory for a cleaner European construction industry. *Journal of Cleaner Production*, 298: 126864.

Assefa, G. & Ambler, C. (2017). To demolish or not to demolish: Life cycle consideration of repurposing buildings. *Sustainable Cities and Society*, 28: 146-153.

Bottero, M., D'Alpaos, C. & Oppio, A. (2019). Ranking of adaptive reuse strategies for abandoned industrial heritage in vulnerable contexts: A multiple criteria decision aiding approach. *Sustainability*, 11(3): 785.

Brooker, G. & Stone, S. (2019). Re-readings: 2: Interior Architecture and the Principles of Remodelling Existing Buildings. Routledge, London, UK.

Bullen, P.A. (2007). Adaptive reuse and sustainability of commercial buildings. *Facilities*, 25(1/2): 20-31.

Camocini, B. & Nosova, O. (2017). A second life for Contemporary Ruins. Temporary Adaptive Reuse strategies of Interior Design to reinterpret vacant spaces. *The Design Journal*, 20(1): 1558-1565.

Celadyn, M. (2019). Interior architectural design for adaptive reuse in application of environmental sustainability principles. *Sustainability*, 11(14): 3820.

Chan, J., Bachmann, C. & Haas, C. (2020). Potential economic and energy impacts of substituting adaptive reuse for new building construction: A case study of Ontario. *Journal of Cleaner Production*, 259: 120939.

Chini, A. R. & Bruening, S. (2003). Deconstruction and materials reuse in the United States. *The future of sustainable construction*, 14: 1-22.

Clarke, N.J., Kuipers, M.C. & Roos, J. (2020). Cultural resilience and the Smart and Sustainable City: Exploring changing concepts on built heritage and urban redevelopment. *Smart and Sustainable Built Environment*, 9(2): 144-155.

Conejos, S., Langston, C., Chan, E. H. & Chew, M. Y. (2016). Governance of heritage buildings: Australian regulatory barriers to adaptive reuse. *Building Research & Information*, 44(5-6): 507-519.

Conejos, S., Langston, C., & Smith, J. (2013). AdaptSTAR model: A climate-friendly strategy to promote built environment sustainability. *Habitat international*, 37: 95-103.

Della Spina, L. (2021). Cultural heritage: A hybrid framework for ranking adaptive reuse strategies. *Buildings*, 11(3): 132.

Dell'Ovo, M., Dell'Anna, F., Simonelli, R. & Sdino, L. (2021). Enhancing the cultural heritage through adaptive reuse. A multicriteria approach to evaluate the Castello Visconteo in Cusago (Italy). *Sustainability*, 13(8): 4440.

Douglas, J. (2006). Building adaptation. Routledge, London, UK.

Elsorady, D. A. (2014). Assessment of the compatibility of new uses for heritage buildings: The example of Alexandria National Museum, Alexandria, Egypt. *Journal of Cultural Heritage*, 15(5): 511-521.

Eray, E., Sanchez, B. & Haas, C. (2019). Usage of interface management system in adaptive reuse of buildings. *Buildings*, 9(5): 105.

Esther Yakubu, I., Egbelakin, T., Dizhur, D., Ingham, J., Sungho Park, K. & Phipps, R. (2017). Why are older inner-city buildings vacant? Implications for town centre regeneration. *Journal of Urban Regeneration & Renewal*, 11(1): 44-59.

Fiorani, D., Kealy, L., Musso, S., Plevoets, B., Houbart, C. & Van Cleempoel, K. (2017). Conservation/adaptation. Keeping alive the spirit of the place. Adaptive reuse of heritage with symbolic value. EAAE, Hasselt, Belgium.

Fiedler, J. & Schuster, S. (2016). The Elbphilharmonie Hamburg. In Kostka, G. & Fiedler, J. (Ed.s), *Large Infrastructural Projects in Germany: Between Ambition and Realities*, 39-85. Palgrave-Macmillan, London.

Fisher-Gewirtzman, D. (2016). Adaptive reuse architecture documentation and analysis. *Journal of Architectural Engineering Technology*, 5(3): 1-8.

Foster, G. (2020). Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. *Resources, Conservation and Recycling*, 152: 104507.

Gusmerotti, N. M., Corsini, F., Borghini, A. & Frey, M. (2019). Assessing the role of preparation for reuse in waste-prevention strategies by analytical hierarchical process: suggestions for an optimal implementation in waste management supply chain. *Environment, Development and Sustainability*, 21(6): 2773-2792.

Hein, M. F. & Houck, K. D. (2008). Construction challenges of adaptive reuse of historical buildings in Europe. *International Journal of Construction Education and Research*, 4(2): 115-131.

Hong, Y. & Chen, F. (2017). Evaluating the adaptive reuse potential of buildings in conservation areas. *Facilities*, 35(3/4): 202-219.

İlerisoy, Z. Y. & Soyluk, A. (2013). Dynamic analysis of Dolmabahce masonary clock tower, *GRAĐEVINAR,* 65(4): 345-352.

Ilerisoy, Z. Y., & Takva, Y. (2017). Nanotechnological developments in structural design: Load-bearing materials. *Engineering, Technology & Applied Science Research*, 7(5): 1900-1903.

Itard, L. & Klunder, G. (2007). Comparing environmental impacts of renovated housing stock with new construction. *Building Research & Information*, 35(3): 252-267.

Kibert, C. J. (2007). The next generation of sustainable construction. *Building Research & Information*, 35(6): 595-601.

Kim, D. (2018). *Adaptive reuse of industrial buildings for sustainability: analysis of sustainability and social values of industrial facades*, Doctoral dissertation, University of Texas at Austin, USA.

Knoth, K., Fufa, S. M. & Seilskjaer, E. (2022). Barriers, success factors, and perspectives for the reuse of construction products in Norway. *Journal of Cleaner Production*, 337: 130494.

Kutlu, İ., İlerisoy, Z. Y., & Soyluk, A. (2022). Sequential approach of the re-using the historical military barrack in the Old Mardin Heritage in Turkey. *Conservar Património*, 40: 104-118.

Langston, C. & Shen, L. Y. (2007). Application of the adaptive reuse potential model in Hong Kong: a case study of Lui Seng Chun. *International Journal of Strategic Property Management*, 11(4): 193-207.

Langston, C., Wong, F. K., Hui, E. C. & Shen, L. Y. (2008). Strategic assessment of building adaptive reuse opportunities in Hong Kong'', *Building and environment*, 43(10): 1709-1718.

Lo Faro, A. & Miceli, A. (2019). Sustainable strategies for the adaptive reuse of religious heritage: A social opportunity. *Buildings*, 9(10): 211.

Love, P. & Bullen, P. (2009). Toward the sustainable adaptation of existing facilities. *Facilities*, 27(9/10): 357-367.

Mahtab-uz-Zaman, Q.M. (2011). Adaptive Re-Use and Urban Regeneration in Dhaka - A theoretical exploration. *Open House International*, 36(2): 45-58.

Mısırlısoy, D. (2011). *Analysis of the Structure and Design Relationship between Contemporary Extensions and Remodeled Masonry Buildings*, Doctoral dissertation, Eastern Mediterranean University (EMU), North Cyprus.

Mısırlısoy, D. & Günçe, K. (2016). Adaptive reuse strategies for heritage buildings: A holistic approach. *Sustainable cities and society*, 26: 91-98.

Monsù Scolaro, A. & De Medici, S. (2021). Downcycling and upcycling in rehabilitation and adaptive reuse of pre-existing buildings: Re-designing technological performances in an environmental perspective. *Energies*, 14(21): 6863.

Mustafa, M. H., Ali, M., Ismail, K. M., Hashim, K. S. H. Y., & Suhaimi, M. S. M. (2019). BIM backed decision support system in the management of heritage building. *International Journal of Built Environment and Sustainability*, 6(2): 63-71.

Niemczewska, Z. E. (2020). The sociocultural impact of adaptive reuse of immovable cultural heritage from the perspective of direct users and the local community. *Journal of Cultural Heritage Management and Sustainable Development*, 11(3): 240-261.

Othman, A. A. E. & Heba, E. (2018). Adaptive reuse: an innovative approach for generating sustainable values for historic buildings in developing countries. *Organization, technology & management in construction: an international journal*, 10(1): 1704-1718.

Pieczka, M. & Wowrzeczka, B. (2021). Art in Post-Industrial Facilities—Strategies of Adaptive Reuse for Art Exhibition Function in Poland. *Buildings*, 11(10): 487.

Plevoets, B. & Van Cleempoel, K. (2011). Adaptive reuse as a strategy towards conservation of cultural heritage: a literature review. In *Structural studies, repairs and maintenance of heritage architecture XII*, 155-163. WIT Press.

Plevoets, B., & Van Cleempoel, K. (2019). Adaptive reuse of the built heritage: Concepts and cases of an emerging discipline. Routledge. London, UK.

Rahmatulloh, O. R., Purwani, O., & Rahayu, P. (2020). The Consumption of Tradition and Heritage Areas in the Grebeg Sudiro Event in Surakarta. *International Journal of Built Environment and Sustainability*, 7(3): 49-58.

Rao, X., Zhou, J., Ding, K., Wang, J., Fu, J., & Zhu, Q. (2022). Research on the cultural tracing of the patriarchal clan system of traditional buildings in the Eastern Zhejiang Province, China, based on space syntax: The case study of Huzhai in Shaoxing. *Sustainability*, 14(12): 7247.

Rodrigues, C. & Freire, F. (2017). Adaptive reuse of buildings: Eco-efficiency assessment of retrofit strategies for alternative uses of an historic building. *Journal of Cleaner Production*, 157: 94-105.

Sandin, G., Peters, G. M. & Svanström, M. (2014). Life cycle assessment of construction materials: the influence of assumptions in end-of-life modelling. *The International Journal of Life Cycle Assessment*, 19(4): 723-731.

Schmidt, R., Eguchi, T., Austin, S. & Gibb, A. (2009). *Adaptable futures: A 21st century challenge*. Paper presented at the proceedings of the CIB Changing Roles: New Roles; New Challenges conference, Noordwijk, The Netherlands, 5-9 October.

Semprini, G., Galli, C. & Farina, S. (2017). Reuse of an ancient church: thermal aspect for integrated solutions. *Energy Procedia*, 133: 327-335.

Sesana, E., Gagnon, A. S., Bertolin, C. & Hughes, J. (2018). Adapting cultural heritage to climate change risks: perspectives of cultural heritage experts in Europe. *Geosciences*, 8(8): 305.

Shehata, W. T. A., Moustafa, Y., Sherif, L. & Botros, A. (2015). Towards the comprehensive and systematic assessment of the adaptive reuse of Islamic architectural heritage in Cairo: A conceptual framework. *Journal of Cultural Heritage Management and Sustainable Development*, 5(1): 14-29.

Shindell, D. T. (2015). The social cost of atmospheric release. *Climatic Change*, 130(2): 313-326.

Šijakovic, M. & Peric, A. (2018). Symbiotic architecture: Redefinition of recycling design principles. *Frontiers of Architectural Research*, 7(1): 67-79.

Smith, S. & Hung, P. Y. (2015). A novel selective parallel disassembly planning method for green design. *Journal of engineering design*, 26(10-12): 283-301.

Soliman, O. A. & Aggour, M. M. (2018). A framework for new architectural additions to heritage buildings. *Journal of Engineering and Applied Science*, 65(6): 423-445.

Stephan, A. & Athanassiadis, A. (2017). Quantifying and mapping embodied environmental requirements of urban building stocks. *Building and Environment*, 114: 187-202.

Suprapti, A., Sejati, A. W., Pandelaki, E. E. & Sardjono, A. B. (2022). Archiving traditional houses through digital social mapping: an innovation approach for living heritage conservation in Java. *Journal of Architecture and Urbanism*, 46(1): 33-47.

Tabak, P., & Sirel, A. (2022). *Adaptive Reuse as a Tool for Sustainability: Tate Modern and Bilgi University Cases*. Paper presented at the Proceedings of the International Conference of Contemporary Affairs in Architecture and Urbanism-ICCAUA, 11-13 May, 5(1): 554-566.

Tafahomi, R., & Nadi, R. (2020). Derivation of a Design Solution for the Conservation of a Historical Payab in the Redevelopment of Doloeei, Gonabad. *International Journal of Built Environment and Sustainability*, 7(1): 1-9.

Takva, Ç. & İlerisoy, Z. Y. (2021). Investigation of Tessellation Patterns in Long-Span Structures. *Gazi University Journal of Science Part B: Art Humanities Design and Planning*, 9(3): 235-249.

Tam, V. W., Fung, I. W. & Sing, M. C. (2016). Adaptive reuse in sustainable development: An empirical study of a Lui Seng Chun building in Hong Kong. *Renewable and Sustainable Energy Reviews*, 65: 635-642.

Tam, V. W. & Hao, J. J. (2019). Adaptive reuse in sustainable development. *International Journal of Construction Management*, 19(6): 509-521.

Tan, Y., Shen, L. Y. & Langston, C. (2014). A fuzzy approach for adaptive reuse selection of industrial buildings in Hong Kong. *International Journal of Strategic Property Management*, 18(1): 66-76.

Toprak, G. K., & Sahil, S. (2021). The Effects of Conservation Policies on New Buildings Designed In Historical Cities–A Case Study in Göynük, Bolu, Turkey. *Gazi University Journal of Science Part B: Art Humanities Design and Planning*, 9(3): 193-215.

Wang, G. & Liu, S. (2021). Adaptability evaluation of historic buildings as an approach to propose adaptive reuse strategies based on complex adaptive system theory. *Journal of Cultural Heritage*, 52: 134-145.

Wang, J. & Nan, J. (2007). Conservation and adaptive-reuse of historical industrial building in China in the post-industrial era. *Frontiers of Architecture and Civil Engineering in China*, 1(4): 474-480.

Wilkinson, S., James, K. & Reed, R. (2009). Using building adaptation to deliver sustainability in Australia. *Structural Survey*, 27(1): 46-61.

Wong, L. (2016). Adaptive reuse: Extending the lives of buildings. Birkhauser, Basel, Switzerland.

Yuan, H. P., Shen, L. Y., Hao, J. J. & Lu, W. S. (2011). A model for cost–benefit analysis of construction and demolition waste management throughout the waste chain. *Resources, conservation and recycling*, 55(6): 604-612.

Yuceer, H. & Vehbi, B.O. (2014). Adaptive Reuse of Carob Warehouses in Northern Cyprus. *Open House International*, 39(4): 65-77.

Yung, E. H. & Chan, E. H. (2012). Implementation challenges to the adaptive reuse of heritage buildings: Towards the goals of sustainable, low carbon cities. *Habitat International*, 36(3): 352-361.

Zahid, A. & Misirlisoy, D. (2021). Measuring place attachment, identity, and memory in urban spaces: case of the Walled City of Lahore, Pakistan. *Journal of Architecture and Urbanism*, 45(2): 171-182.

Zaleckis, K., Draooğan, H. A., & Arce, N. L. (2022). Evaluation of the Interventions to Built Heritage: Analysis of Selected Façades of Kaunas by Space Syntax and Sociological Methods. *Sustainability*, 14(8): 4784.