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Adaptive Reuse of Existing Buildings: Contemporary Relevance

Nischal Dotel

Oxford College of Engineering and Management, Pokhara University, Nawalparasi, Nepal
*Corresponding E-mail: nischal.dotel19@gmail.com

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Abstract

Adaptive Reuse (AR) is repurposing the existing buildings by making changes in the architecture accordingly. It is one of the most efficient construction techniques. The building construction takes a big amount of money and time as well as making a credible impact on the environment. This paper aims to conclude the contemporary relevance of this method in terms of sustainability. With the help of a qualitative research methodology, this study focuses on examining the overall relevance of Adaptive Reuse as a sustainable approach to civil engineering constructions. Several implications of repurposing around the world have been studied to come up with an understanding of the modern relevance of AR. Based on the case study of several repurposed buildings, and a site observation the relevance and suitability of this method is concluded in this paper. Adaptive Reuse can be even more efficient if factors like structural integrity and historical credibility are considered. Maintaining the originality of buildings by using similar materials and renovating buildings to match the original theme of the buildings can help to preserve the historic architectural value along with meeting contemporary requirements. Proper structural treatment should also be applied to further increase the lifespan of the building. The structural treatment may include adding new structural members or repairing the existing ones.

Keywords Adaptive reuse, architecture, material reuse, structural treatment, sustainability.

1. Introduction

The construction of a building is a complex process. It takes an enormous amount of time, money, and resources to execute the construction of any building. It also has a detrimental influence on the environment. According to a report from 2019, the building construction sector is responsible for 36% of total energy use, and 11% of it is accounted for the production of materials like steel, cement, etc alone (Abergel et al., 2019). Increasing population and urbanization are culpable for a rapid rise in construction works. There have been many solutions proposed so far by several agencies. Green buildings and timber structures are some of the highly adopted techniques as the solution for environmental impacts accounted for building construction. Adaptive reuse of existing buildings can be the most effective approach for saving the environment from the negative impacts of building construction and also we can save some resources on top of that.

Adaptive reuse is an act of repurposing the existing buildings as they were intended

initially. It is the process where the buildings, especially old ones are modified according to the purpose. If the building holds adequate structural stability, it can be redesigned to use instead of construction the whole other building. The technique of adaptive reuse has been initiated in response to the rapid increase of urbanization. The adaptive reuse of an existing structure can play a crucial role in minimizing the environmental impacts as well as in saving resources and promoting sustainability in the field of civil engineering. There have been a lot of challenges seen while adopting the adaptive reuse method. Major obstacles that have been seen are affiliated with structural engineering. Lack of structural stability and outdated material strength in the structure are the major issues noticed in the technique. Many aspects like dimensional suitability, site location, etc need to be addressed before even planning for the adaptive reuse and they stand as the major hindrances while repurposing the buildings. With the critical analysis, this paper focuses on the suitability of this method by analyzing the existing practices of the method. There are a whole lot of factors to be considered while repurposing the old buildings. The major concern while redesigning the building is not to interfere with the originality. The Adaptive Reuse should be done in a manner that still maintains the historic value while blending the building with modern architecture. This paper also aims to perform a comprehensive case study examining the possibilities and drawbacks.

2. Statement of the problems

The construction of any building takes a huge amount of material, resources as well as manpower. In addition, construction also has a huge impact on the environment. The building can be constructed sustainably in terms of strength and stability but the environmental impact it leaves behind cannot be left unaddressed. As most of the materials used in construction are factory-produced, they raise both direct and indirect impacts on the environment. And even if we somehow managed to perform the construction works in an eco-friendly way, there are a lot of other issues to address. Cost of materials, availability of the materials and land, pre-studies, manpower, and so on are the other crucial factors to be considered in the construction. There have been a lot of solutions proposed so far, but the feasibility of those solutions was low. Being one of the most effective solutions, adaptive reuse has not been seen a lot in practice. In the places where it has been used, a lot of issues have been seen. This paper aims to analyze the feasibility of adaptive reuse by studying several cases where it has already been successful in practice.

3. Objectives

The major objectives of this paper are:

- To explore the adaptive reuse technique along with its on-site implementation.
- To critically analyze the feasibility, comparing the suitability and drawbacks of adaptive reuse.
- To analyze the relevance of AR in terms of sustainability.

4. Methodology

The purpose of this research is to analyze the possibility as well as the suitability of the adaptive reuse of old buildings. This paper uses the qualitative research technique and case study method to comprehensively analyze the suitability, merits, and drawbacks of the adaptive reuse technique. The analysis of multiple implemented projects by case study and site visit has been done for the collection of data.

For the interpretation of data, a case study of multiple projects has been compared. The findings from several studies have been cross-synthesized by identifying the patterns, common themes, and divergent outcomes. To sum up, a conclusion is obtained after the critical evaluation of all the outcomes.

5. Literature review

The concept of Adaptive Reuse is not novel. It has been used for centuries. There have been a lot of studies regarding this technique. The suitability, merits, drawbacks, and feasibility studies have been done and concluded by many researchers. Some of the previous publications have been reviewed in this paper for a better understanding of the subject.

Arfa et al. (2022) aimed to identify the steps involved in the AR process. The major focus of this study was to develop a structured model that can help preserve the historic value of an archaic building. The review on an international level has been done to analyze the application of AR throughout the world. The model concluded by this paper can act as the basis for further studies affiliated with an AR process (Arfa et al., 2022).

Aydemir & Akın (2024) studied the rise in office vacancy rate and housing inequality. The major goal of this study was to examine the potential of vacant office buildings to be repurposed. Case studies of several buildings being reused have been done in this study to examine the potential and challenges (Aydemir & Akın, 2024).

Vafaie et al. (2023) did a systematic review of relevant articles to the Adaptive Reuse published online. The major goal of this paper was to study the success factors of an AR. These success factors can be used to analyze the efficiency and feasibility of repurposing heritage buildings. An Adaptive Reuse is potentially successful if it falls into the scope of sustainability, which was the crucial finding of this study. The results of this research can assist the decision-making process and help to shortlist the factors to be considered for an efficient AR (Vafaie et al., 2023). Triratma et al. (2023) did the case study research in the De Tjolomadoe building in Surakarta City, Indonesia. The former sugarcane factory has been converted into a tourist destination and a meeting place. This study aimed to determine the aspects to be considered so that the reuse of old buildings can be sustainable. This study also concluded that the method of AR can be highly efficient and sustainable if all aspects have been properly considered (Triratma et al., 2023).

Mohamed et al. (2017) analyzed the relationship between sustainability and AR in terms

of economy, ecology, and equity. This research was also based on the literature review to collect information regarding Adaptive Reuse. This study critically examines whether the AR method is supported by sustainability. This study found that there is still some incorporation between AR and sustainability in terms of equity. Policy intervention to address the equity issue in Adaptive Reuse was suggested by this study (Mohamed et al., 2017). Silva & Perera, (2016) aimed to study the barriers and challenges of an Adaptive Reuse process. The global trends were studied to comprehensively analyze the process. The social, Environmental, and Economic benefits of this process have also been well-studied in this paper. The AR has more benefits than drawbacks, thus it is highly important to overcome its challenges and to set the worldwide trend of the Adaptive Reuse (Silva & Perera, 2016).

Plevoets & Cleempoel (2011) used three main approaches: Technical, Typological, and Strategic approaches to review existing research. The theoretical development of the concept of AR has been well analyzed in this paper. This study categorized the buildings into several typologies and indicated different sources dealing with each typology. This paper also critically studied the technical issues like load bearing, comfort, safety, and energy efficiency of repurposed buildings. Overall, this study is affiliated with theoretical research rather than practical applications (Plevoets & Cleempoel, 2011).

Shakya & Tiwari (2021) assessed the repurposed buildings in Patan, Nepal in terms of factor based on existing literature and the context of patan. After observing the relevance of sustainability assessment mostly in new constructions, author analyzed the applicability of sustainable approach like AR in traditional homes and inn. The study was also an attempt to observe the methods and materials that are being used in the existing adaptive reuse buildings and its impacts. The major finding of this research was that the complete new construction of similar built up area would consume 2.15 to 3 times of embodied energy and 2.62 times to 3.7 times of emitted carbon (Shakya & Tiwari, 2021).

6. Study of current practices

There have been a lot of implications of Adaptive Reuse on national as well as international levels. Large-scale organizations like Google, Apple, and many others are adopting this method for their buildings. From the local level to the international level, the AR method can be seen in implications. Some of the cases where it has been studied in this paper.

6.1 Google headquarters, Los Angeles

Google has adapted the method of adaptive reuse for the construction of its LA headquarters. A historic building made in 1943 has been repurposed as a modern office space. The building was originally designed as the construction place for the Hercules IV airplane, commonly known as the "Spruce Goose," which was intended

for military transport during World War II (Baldwin, 2018). In the 1990s, the hangar was converted into a film production facility. Google began leasing the facility in 2016 and hired Oregon-based company, ZGF to transform the interior according to the need (McKnight, 2018). Its wooden structure is what gives this building, high historic value. The original wooden (Timber) structure has been restored maintaining its architectural integrity after ensuring its structural stability. The modern touch on the iconic styles from the era of the 1940s makes this building architecturally unique. Some architectural changes have been applied to keep up with contemporary office needs. The aviation-themed rooms have also been introduced to honor the hanger's history. The walkway around the perimeter has also been introduced to help people move around easily. The central axis of a hanger is refurbished to include café and collaboration. A new open floor plate has been designed to allow light to penetrate through all levels. The custom-made furnishings, vibrant art installations, and aviation-themed rooms were introduced to maintain the historical ambiance (Baldwin, 2018).

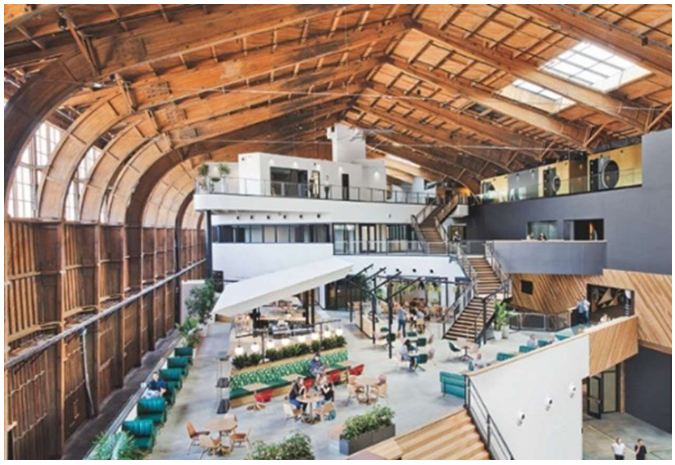

Figure 1 Google's new LA office *(Cohen, 2019)*

6.2 Moritzburg museum, Germany

The Moritzburg Museum of Halle, Germany is one of the best examples of adaptive reuse buildings. The ancient castle has been extended and transformed into a museum, preserving its ancient value. The building holds crucial historic value as it is one of the few buildings left that are affiliated with the gothic military architecture, typical of Germany at the end of the 15th century. Despite having a turbulent history and undergoing many alternations over the centuries, the building still preserves its original architectural features like the surrounding walls, round towers, and central courtyard (Frearson, Moritzburg Museum Extension by Nieto Sobejano Arquitectos, 2011). There have been applied few changes to meet the features accordingly. The new roof has been designed in a way that allows the natural light to enter easily. The roof was redesigned

Figure 2 Mortizburg Museum *(Mohr, 2019)*

without interfering with the original floor design. An angular metal tower has also been added along the castle's existing irregular shape providing a geometric appearance. The major engineering challenge while repurposing this building was to expand the space without providing an additional structural member, column. However, this issue has been cleverly managed with the clear architectural idea of a new roof (Badalge, 2018). The renovation with extension also includes the metal-entrance addition of a trapezium shape (Frearson, Moritzburg Museum Extension by Nieto Sobejano Arquitectos, 2011).

6.3 Apple tower theatre store, Los Angeles

Apple, one of the top tech companies has done an excellent repurposing of the 1920s building. Over a century-old movie theatre which was abandoned after 1988 has been redesigned by Apple (Block, 2021). The design seeks to reawaken La's one of the most historic movie theatres by repurposing and restoring its lost glory. The theatre was the first one to feature the talking movies in Los Angeles. The major purpose of this project was the urban regeneration of downtown LA, which will improve urban retail and public life in this part of the city (Pintos, 2021). While renovating, the building's terracotta facade (exterior surface) has been thoroughly cleaned and repaired, ensuring the preservation of historic character while looking fresh. The theatre's unique corner clock tower was restored to its original design, ensuring it remained a crucial architectural feature. The original materials such as marble columns, bronze handrails, and detailed plasterwork have been cleaned, repaired, or replaced with similar materials, maintaining the historic similarity. The main floor, previously used as the orchestra seating area, was transformed into an open retail space. Along with the architectural redesign, the structural treatment is also applied to ensure stability. The original balconies have been reinforced which now serve as spaces for hosting workshops and presentations. The modern retail technology and Apple's design elements were coherently integrated into the historic framework without compromising the building's character (Block, 2021). There are a lot of other features added, restored, repaired, or blended according to the need which makes this building one of the best examples of adaptive reuse.

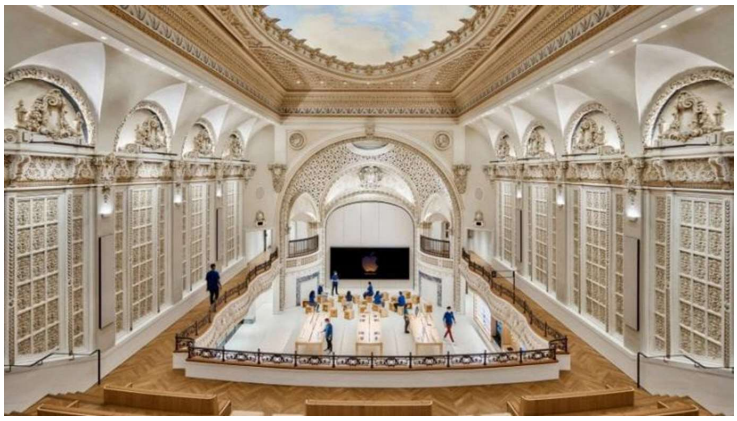

Figure 3. Apple Tower Theatre, LA (Pintos, 2021)

6.4 Danish national maritime museum

Opened in 2013, the Danish National Maritime Museum blends history with modern architecture. The original purpose of the building was a dry dock. The dry dock was

Figure 4. Danish maritime museum (Rosenfield, 2014)

used for the construction, maintenance, and repair of the ship since 1883. The building was functioning until its closure in the 1980s. The building then has been transformed into the museum which now serves as the major attraction in the city of Helsingor, Germany (GLANCEY, 2014). Instead of destroying or filling the dry dock, the site has been repurposed as the central courtyard of the museum, preserving its historical structure. The museum has been built around the original walls of the dry dock, leaving them intact. The design is done in a manner that new construction is mostly invisible above the ground. A series of bridges are cut into the dock walls, creating a functional and aesthetic connection between different parts of the museum while maintaining structural integrity. These bridges are also used as auditoriums and galleries. One of the major challenges while designing was not to interfere with the view of the nearly located Kronborg Castle with huge historic value. As the solution, the museum's above-ground parts, like the bridges and entrance, are small and low, making sure the castle stays the main focus of the area (Frearson, Danish National Maritime Museum by BIG, 2013). There have been a lot of other changes blending the history with the modern architecture.

7. Discussion and recommendations

The comprehensive case studies have been done in this paper on several on-site implications. After several case studies, the method of Adaptive Reuse seems to be one of the most promising solutions for the environmental impacts of engineering constructions. Every approach has its pros and cons. However, on the proper analysis, the AR method appears to have more benefits than drawbacks in terms of sustainability (Silva & Perera, 2016). As supported by Vafaie et al. (2023), the process of AR can be highly efficient if the relevant success factors are properly considered (Vafaie et al., 2023). All over the world, the application of an Adaptive Reuse method has been seen as highly effective and fruitful where the initial theme of the building has been preserved. The repurposing of old buildings has a hugely beneficial influence in terms of materials and resources. The cost of any construction project is automatically reduced as the major criteria of expenses are eliminated. The budget for the maintenance of the site earth and material cost is almost completely eradicated. The manpower and resources are also reduced to a very high extent while adopting the repurposing approach. After the critical evaluation, Adaptive Reuse seems to be highly sustainable.

Despite being extremely effective, some of the issues still there to be addressed in this method. In some cases, the historic value of the building is completely demolished. The buildings surely do get a new purpose, but the originality of buildings is lost if the proper considerations are not made. To take care of the similarity, similar materials can be used while renovating the building for the new purpose. The use of cladding materials like tiles, plastering, and paints according to the initial condition of a building can preserve the theme of the building, maintaining its historic value. The proper examination of the initial purpose of the building can also give a whole lot of ideas regarding the building itself. These details can now be used in replicating the original architecture of the building. Another obstacle to the successful implementation of the AR process is structural stability. With an increase in age, buildings start losing their structural strength. Proper treatments are done to increase or maintain the structural strength of the building. The addition of new structural members like columns or using the method of underpinning to strengthen the foundation can make a huge impact on the structural stability of the building and it can last for a longer time. On a final note, Adaptive Reuse can be the best step toward environmental conservation and sustainable development if it is done with proper consideration of its success factors. Proper policies are recommended to be designed at the international level for the advancement of the adaptive reuse method.

8. Conclusion

This paper aimed to study the relevance of the AR method in current-day construction. Accordingly, the method is proven as a highly sustainable solution for the environmental impacts of civil engineering constructions. After studying several cases, this method seems to be highly promising in minimizing the environmental footprints of construction projects. Repurposing the existing not only has a positive impact but also has huge economic benefits. Major expenses like site preparation and labor costs are reduced to a very high extent, making the construction budget-friendly. Along with the cost, resources, and manpower are also substantially reduced. As we don't have to construct a building from the base, resources are also saved. The root of the concept of Adaptive Reuse was the preservation of historic buildings. By repurposing an existing building, its historic value can be preserved while still being used for several projects.

There is still a huge area for advancement of the Adaptive Reuse method. In some cases, buildings seem to lose their originality completely. There are various simple solutions to it. Using similar materials while renovating, redesigning the building in the original theme, etc can make repurposing effective by maintaining the historic value. Most of the projects of Adaptive Reuse seem to be facing structural issues which is another major issue to be addressed. Several advanced methods for structural treatments can be applied as the solution. lack of policies is also something to be taken care of in this field. Proper policies should be made for the upliftment of the AR method.

On the whole, Adaptive Reuse can be proven to be the most noticeable step toward environmental conservation and sustainable development in terms of civil engineering and architecture.

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