

Nexus Between the Concepts Used for Enhancing the Sustainability of Existing Buildings

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Abstract - The significant portion of the building stock required for the future is already in existence. Demolishing existing buildings and constructing new ones is also not sustainable. Thus, the existing buildings need improvement towards sustainability. Various interconnected concepts which represent the sustainable performance of existing buildings seemed to have emerged and evolved in practice. The most suitable concept for achieving the sustainability of existing buildings is still not clear. Hence, this study aims to examine the relationship between the various concepts which represent the sustainable performance of existing buildings. A systematic literature review was conducted to explore the concepts. Five main concepts: adaptive reuse, retrofit, renovation, refurbishment, and circular economy were selected. As per the review, each of these five concepts has a distinct meaning, however, they are similar in extending the lifetime of a building to attain sustainability. The concepts of adaptive reuse, renovation, and refurbishment are attributed to the end-of-life stage of an existing building while retrofit refers to the operational stage of a building. Contrarily, the circular economy concept is applied to through life cycle stages of a building as well as its day-to-day operations. In addition, the circular economy is a much broader concept that encompasses other four concepts as part of its principles. This signifies that the adoption of the circular economy concept into the existing buildings would contribute more towards enhancing their sustainable performance.

Keywords: *Adaptive reuse, Circular economy, Existing building, Refurbishment and Renovation, Retrofit, Sustainability.*

I. INTRODUCTION

Building sector is one of the least sustainable industries since it uses a lot of resources and energy, contributing significantly to greenhouse gas emissions, resource scarcity, human-induced climate change, etc. [1]. On the other hand, [2] indicated that much of the building stock required for the next century already exists, and thus, existing building stock needs to be carefully managed to make a significant impact on sustainability. In addition, upgrading the existing buildings is more sustainable than constructing new buildings [3], since it prevents the growth of built areas and minimises material consumption and waste generation also allows for the preservation of the location's unique identity [4]. Moreover, existing buildings are seldomly considered for deconstruction, and also, less than 1% of that available today can be fully demountable [5]. As a result, various concepts have been put into action to enhance the sustainability of existing buildings. For example, adaptive reuse is strongly believed to enhance the sustainability of existing buildings as it encourages the maximum reuse of components and restoration of passive aspects of the original building [6]. In addition, one of the key benefits of adaptive reuse is that it preserves the embodied energy (the energy required to construct a construction project) of the original building [7]. Another example, retrofitting an existing building is a way to improve its sustainability [8]. It helps to improve energy and environmental efficiency by using less water and enhancing the quality of the air and natural lighting in the area [8]. A further instance, refurbishment of the existing house buildings requires less embodied energy (5.66 GJ/m²) compared to the construction of a new house which requires 7.27 GJ/m² [9]. However, these concepts appear to be connected, and the concept that makes existing buildings more sustainable is still not clear. Thus, this

study aims to investigate the nexus between these concepts for enhancing the sustainable performance of existing buildings.

II. METHODOLOGY

A systematic literature review was carried out to extract the alternative concepts used to represent the sustainable performance of existing buildings. In conducting this search, the search term "sustainable performance" AND "existing building" was used and turned up 53 and 71 papers in Science Direct and Google Scholar databases, respectively. This next section presents the review outcome in terms of the focus of the study.

III. RESULTS AND DISCUSSION

This section discusses the links established between the five concepts considered; adaptive reuse, retrofit, renovation, refurbishment, and circular economy (CE).

All five concepts are unique in terms of their meanings and coverage. Adaptive reuse refers to a significant change of an existing building function when the former function has become obsolete [10] while retrofit is defined as any work to a building over and above maintenance (e.g., adjust, reuse, upgrade) to change its capacity, function, or performance to suit new conditions or requirements [11]. Then, refurbishment is the set of interventions aimed at transforming the building through a systematic set of works that can lead to a building totally or partially different from the previous one [12]. Although renovation is commonly misunderstood as a kind of new construction, as per Cambridge Dictionary, it is "the process of repairing and improving a building so that it is in good condition again or the improvements that are carried out". Moreover, retrofit denotes significant physical alterations to buildings and used for whole or parts of a building that is currently in operation. Renovation is transforming an existing building into something new, whereas refurbishment involves polishing or restoring an existing building to a good condition. CE is defined as the use of practices in all stages of the life cycle of a building to keep the materials as long as possible in a closed loop to reduce the use of new natural resources in a construction project" [13]. To conclude, retrofit is applied in the operational stage of an existing building, whilst adaptive reuse, renovation, and refurbishment are performed at the end-of-life phase. On a different note, the CE concept is applied to a building's through life cycle stages as well as its day-to-day operations of it. In addition, the building will be like new or serve a different purpose after applying adaptive reuse, in contrast, buildings will serve the same function as before while they will be like new after applying the renovation concept.

However, all these concepts share the goal of prolonging the useful lives of buildings. For example, adaptive reuse is giving outdated structures, particularly historic structures a new life without unnecessary and premature destruction. It also preserves the buildings' cultural heritage value while extending their lifespan [10]. Similarly, the refurbishment has the potential to increase a building's lifespan instead of adopting new construction plans [3] while retrofit entails changes to the built environment's fabric, shape, and systems that go beyond the frequently invisible maintenance and repair, hence helping

to extend the life of a building [14]. The ultimate aim of CE is to extend the life of a building [13], while the renovation of a building is expected to improve comfort and quality of life [15].

The ultimate aim of all five concepts is to achieve sustainability through various means of upgrading existing buildings. Adaptive reuse plays a key role in lowering emissions since it requires less energy and generates less waste than traditional demolition and reconstruction [10]. In addition, it provides significant social and economic benefits to society. Similarly, retrofit is primarily aimed to reduce the buildings' energy consumption while improving indoor environmental quality and minimising harmful emissions. Consequently, adopting it has the potential to generate a net economic benefit, simultaneously benefitting the environment and society at large [8]. CE is a practical solution to unsustainable practices which is achieved through maximizing the use of materials and preserving their value as long as possible, rather than using natural resources and disposing of them as waste [3]. Likewise, renovation and refurbishment are reducing adverse environmental effects, boosting economic viability, and as a result, improving societal well-being [12; 15]. Table 1 depicts the conceptual link between the considered five concepts.

Table 1. The conceptual link between concepts representing enhancing the sustainable performance of existing buildings

Criteria	Adaptive reuse	Refurbishment	Renovation	Retrofit	Circular Economy
Meaning	Give new life to outdated building	Restore an old building to a good condition	Transform existing buildings into something new	significant physical alterations to a building	Close the resource loop (reduce the use of new resources)
Objective	Extending the life of existing buildings toward Sustainability				
Building stage	End-of-life			Use	All stages
Building purpose	Change	No change			Both
Applicable to day-to-day operation	No: Occasionally during the building's lifetime				Yes: Throughout the use stage

Furthermore, the implementation of CE is being pursued through the use of the R-imperatives, which vary in quantity and order and also have changed over time [16]. Source [16] established a framework of R-imperatives (with 11Rs) of CE for the built environment, which includes refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover, and replace. Here, all four of the other concepts can be put into "refuse and reduce" (defined as avoiding or less creating materials as waste/consumption of any virgin materials). The concept of refurbishment is explicitly having the same meaning. Then, adaptive reuse can be categorised under reuse. Next, reconditioning and renovation are practically the same. Finally, the retrofit can be included into replace. Therefore, the CE includes the other four concepts as one of its principles. This reveals that the CE concept must be included in existing buildings to enhance their sustainability. However, research on the applicability of these principles as a whole to existing buildings is still lacking.

IV. CONCLUSIONS

The importance of this trend of adopting above mentioned concepts is to extend the useful life of existing buildings which supports the key concepts of sustainability through various means of upgrading the existing buildings. Accordingly, all of these concepts are based on the same idea, which is primarily to extend a building's lifetime. Further, since the concept of CE may integrate through its various principles, the rest of the four concepts can be incorporated into CE. Thus, it is necessary to promote its association with buildings to attain sustainability.

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