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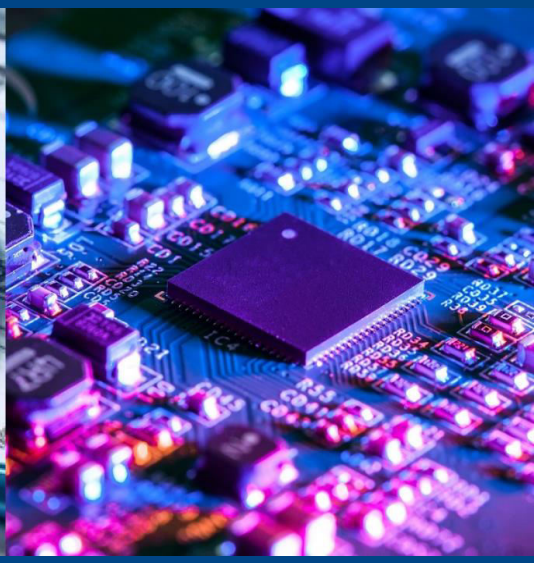

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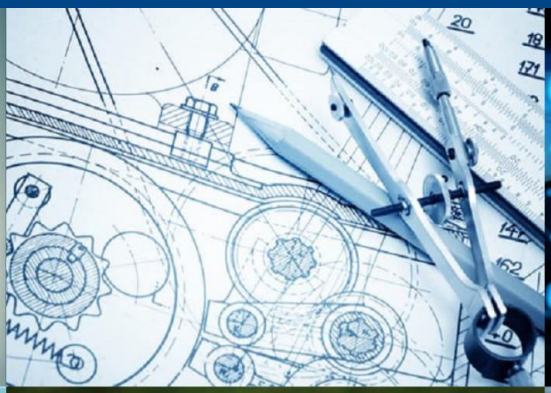

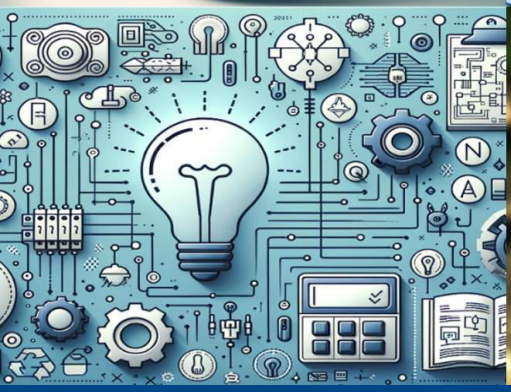

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A Review on Implementation of Role of Circular Economy Principles in Sustainable Construction Practices

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ABSTRACT: Circular economy principles in construction focus on creating a system where resources are used efficiently, waste is minimized, and materials are reused or recycled, aiming to reduce environmental impact and enhance sustainability. This research explores the pattern of C.W. generation and its relationship with physical, organizational, and behavioral aspects in the construction process as a whole. It argues that current C.W. management practices are linear, where architectural interventions can play a significant role in adopting a C.E. based approach for environmental sustainability

I. INTRODUCTION

The construction industry is one of the significant contributors to the global economy that significantly contributes to a country's development process providing necessary public infrastructure and structures for residential, various productive activities such as services, commerce, industries, and other utilities. On the other hand, building and infrastructural facilities and subsequent construction activities consume excessive mineral resources. The depletion of natural resources by the building industry is a matter of grave concern as most of the recyclable material from building sites ends up in landfill sites. Thus, optimization of materials consumption and generation of waste by construction activities is indispensable to sustainable development. Construction waste (C.W.) management involves four hierarchical steps reduce, reuse, recycle and recover.

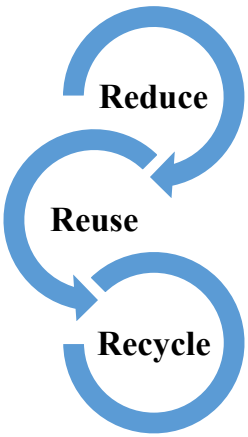

Fig 1 Circular Economy Principle

A. Minimize Waste Generation

- **Waste Reduction during Construction:** Minimize construction waste by rethinking the way materials are used and cut. For example, precise measurements and more accurate planning help reduce material waste.

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- **Reusing and Recycling Materials:** Use reclaimed or recycled materials in the construction process. This reduces the demand for virgin resources and keeps waste out of landfills.

B. Use of Renewable and Recycled Materials

- **Sustainable Material Sourcing:** Use materials that are renewable, recyclable, or biodegradable. For instance, recycled steel, reclaimed wood, and low-carbon concrete.
- **Local Sourcing:** Sourcing materials locally reduces transportation costs and emissions, contributing to a smaller carbon footprint.

C. Benefits of Circular Economy in Construction:

- **Environmental Impact Reduction:** Lower greenhouse gas emissions, reduced resource extraction, and less landfill waste.
- **Cost Savings:** Reduced costs through material reuse, recycling, and efficient resource management.
- **Innovation Opportunities:** Encourages the development of new, sustainable materials and construction techniques.
- **Resilience:** Creates a more resilient construction sector that can adapt to changing environmental and economic conditions.

II. STATE OF DEVELOPMENT

Salim Barbhuiya et. al. (2024) this comprehensive review explores the integration of circular economy principles into the concrete industry, emphasizing their role in enhancing sustainability and resource efficiency. It covers the fundamental concepts of circular economy and examines the application of Life Cycle Assessment (LCA) in evaluating the environmental impacts of concrete production. The review highlights innovative strategies for recycling, reuse, waste reduction, and resource optimisation, showcasing how these approaches can transform concrete production practices. It also addresses the policy considerations, economic implications, and societal impacts associated with adopting circular economy practices. Furthermore, the review investigates recent technological advancements in circular concrete production, including self-healing concrete and 3D printing. By summarizing these findings and offering practical recommendations, the review aims to support the industry in transitioning towards more sustainable practices. This detailed analysis provides valuable insights into the benefits and challenges of circular economy adoption, helping stakeholders make informed decisions for a greener concrete sector.

Masoud Norouzi et. al. (2021) The building industry is responsible for considerable environmental impacts due to its consumption of resources and energy, and the production of wastes. Circular Economy (CE), a new paradigm can significantly improve the sustainability of this sector. This paper performs a quantitative scientific evolution analysis of the application of CE in the building sector to detect new trends and highlight the evolvement of this research topic. Around 7000 documents published 2005 to 2020 at Web of Science and Scopus were collected and analysed. The bibliometric indicators, network citation, and multivariate statistical analysis were obtained using Bibliometrix R-package and VOSviewer. The co-occurrence analysis showed five keyword-clusters, in which the three main ones are: (i) energy and energy efficiency in buildings; (ii) recycling, waste management and alternative construction materials; (iii) sustainable development. The analysis showed that researchers pay close attention to “sustainability”, “energy efficiency”, “life cycle assessment”, “renewable energy”, and “recycling” in the past five years. This paper highlights that (i) the development and use of alternative construction materials; (ii) the development of circular business models; (iii) smart cities, Industry 4.0 and their relations with CE, are the current research hotspots that may be considered as potential future research topics.

Kamel Mohamed Rahla et. al. (2021) Population growth, along with a rapid urban expansion, is imposing a heavy pressure on the planet’s finite resources. It is widely acknowledged that the building industry consumes large amounts of raw materials while generating waste and emissions. To set apart economic growth from environmental repercussions, the Circular Economy (CE) arose as an innovative paradigm that can offer a fast-track towards a sustainable built environment. This paper will tackle a research gap that academia and policymakers often highlighted, which is how can we apply CE to assets that are predominantly meant to be demolished and their resources wasted when they reach their end-of-life. Globally, the paradigm aims at erasing the waste concept, relying on renewable and regenerative sources, and keeping the materials, components, and systems in use at their highest value as long as

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possible. The concept's implementation would attempt to consider the built environment as a closed-loop system wherein resources are viewed as a scarce commodity. Although the CE seems straightforward, translating the circular thinking to the building level might be a hardship. The following paper will attempt to shed light on how to promote CE in buildings that will ultimately lead to healthier, more efficient, and more sustainable cities on a broader scale. The proposed framework considers CE implementation strategies throughout the building's lifecycle and mainly deals with three innovative aspects: wise resource management, building design approaches, and digitalization of the building industry. In this sense, this study will explore these game-changing factors that are considered paramount to concretize the concept in practice and provide a smooth pathway for CE uptake in buildings.

Martin Marek et. al. (2024) This article explores the role of the circular economy in achieving sustainability in the construction industry, with a focus on cost reduction. Sustainable building practices are vital for addressing environmental concerns, and the circular economy offers transformative solutions. By emphasizing reuse, recycling, and responsible resource management, the circular economy reshapes traditional construction approaches. The paper examines how adopting circular economy principles can significantly reduce costs throughout a building's life cycle. It discusses case studies and successful implementations, showcasing innovative strategies to minimize waste and optimize resource use. Topics include integrating circular economy practices in design and construction, the economic benefits of material reuse and recycling, and the long-term financial advantages of sustainable building. The article highlights the importance of stakeholder collaboration, policy frameworks, and technological innovations in driving circular economy adoption. By demonstrating the economic benefits of sustainable building through the circular economy, this article aims to promote environmentally conscious construction practices and inspire stakeholders to embrace cost-effective and sustainable solutions for a greener future.

Bernard Anim Manu et. al. (2024) The integration of modular construction and circular economy principles represents a transformative approach to sustainable urban development, addressing the growing need for environmentally responsible, resource efficient, and resilient cities. As urban populations continue to increase globally, the construction industry faces immense pressure to meet the demand for housing and infrastructure while reducing environmental impact and resource consumption. Modular construction, with its offsite prefabrication and assembly process, offers significant advantages in terms of reduced waste, faster build times, and greater precision. When combined with circular economy principles such as the reuse, recycling, and repurposing of materials this approach can significantly enhance the sustainability of urban developments. Modular construction facilitates the efficient use of resources by allowing for standardized designs and easy disassembly, which aligns with circular economy goals. By integrating principles such as material longevity, waste minimization, and the consideration of end of life cycles, the construction process can reduce its carbon footprint and contribute to a more sustainable built environment. Additionally, modular construction's flexibility allows for the adaptation and repurposing of structures, reducing the need for demolition and fostering longer lasting, adaptable urban spaces. This paper explores the potential of combining modular construction with circular economy principles in urban planning, assessing the environmental, economic, and social benefits of such integration. By examining case studies and current practices, the paper highlights how these innovations are being implemented in real world urban projects and outlines the challenges and opportunities for further adoption. Ultimately, this approach promises to shape the future of urban development, creating more sustainable, efficient, and adaptable cities for future generations.

Motasem Y. D. Alazaiza et. al. (2024) Waste generation from the construction industry has been recognized as a key factor in environmental deterioration. Excessive waste in the construction field is a direct outcome of unsustainable production and consumption practices, typically ending up in landfills. To tackle this problem, a circular economy management approach has been proposed as a solution for sustainable construction and demolition waste management. This review outlines the strategy of the circular economy to promote sustainable management of construction and demolition waste. The circular economy management strategy emphasizes the importance of reducing waste production and promoting the reuse and recycling of materials. This approach also promotes the use of sustainable materials and the implementation of effective waste management practices during construction and demolition. The circular economy management approach to sustainable handling of construction and demolition waste involves several key strategies. These include embracing sustainable design and construction methods, encouraging material reuse and recycling, and establishing efficient waste management systems. These strategies require the cooperation and involvement of all stakeholders in the construction and demolition process, including architects, contractors, developers, and waste management companies. The circular economy management approach provides a promising framework for achieving

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the objectives of effective waste management and sustainable construction. By promoting sustainable patterns of production and consumption, this approach can reduce the environmental impact of the construction industry while generating economic benefits for stakeholders. However, successful implementation of this approach requires strong regulatory support and the willingness of all stakeholders to adopt sustainable practices.

A'izzatul Khiyana et. al. (2024) Building projects often generate significant amounts of waste. This happens because the building projects mostly adopt a linear economic model of "take, make, dispose of", using materials to the construction of buildings and disposing of them at the end of life. This linear economic model only focuses on human activities because the disposal of materials ultimately does not become a sustainable practice in the future. For this reason, an alternative is needed in reducing and processing construction waste by implementing circular economy principles. This study aims to identify type of construction waste in building projects, provide recommendations for handling it with circular economy principles, and calculate the cost savings. The methods that used in this study are field observation and interview for collecting data. The result showed that steel reinforcement, ready-mix concrete, light brick, ceramic, multiplex, spun pile, and anchor can be handled with circular economy principles are reduce, reuse, recycle, recovery, and repair. The cost savings from handled it in project A, B, and C are Rp. 68.252.490,65, Rp. 84.182.684,96, and Rp. 31.794.238,51, respectively.

Muhammad Saroosh et. al. (2024) Construction industry is one of the greatest contributors to global waste and resource depletion. Traditional construction practices generate a lot of waste which is a big environmental challenge. This requires moving to sustainable strategies especially adopting circular economy concepts to address these urgent matters. In the next nine years, the globe will produce 2.2 billion tons of construction and demolition waste, necessitating a reassessment of the traditional methods. Waste accumulation and environmental pollution are also aggravated by the conventional linear approaches in construction which follow the 'take-make-dispose' model. Circular economy as a viable alternative promotes a regenerative system which maximizes the flow of materials through reduction of waste, re-use, recycling, and refurbishment. The purpose of this study is to develop a comprehensive implementation framework for circular economy based on construction waste management. It aims to identify major materials contributing to construction waste and determine the possibility of using these materials in the construction industry. The research intends to examine the need of adopting a circular economy in construction projects by focusing on waste reduction strategies, material reuse, and innovative resource efficiency in construction. It aims to offer ways of effective sorting, the reuse of materials and the incorporation of recycled materials into new constructions. By questionnaire survey, trend analysis and stakeholder consultation, this study aims to provide inputs and a strategic roadmap for the application of circular economy principles in waste management from the construction field. In principle, it promulgates sustainability and low carbon footprint in the built environment.

Mamilla Vijaya Kumar et. al. (2024) Building construction and operation have been associated with many environmental issues, such as contamination of the surrounding area and overuse of world resources. The world's environmental degradation issues have compelled society to reconsider its methods of development and expand the notion of sustainable development. Green building has an important impact on building design, so it should be emphasized. Growing environmental concerns have given green and sustainable buildings a lot of attention in recent years. Developed and developing nations each have their own evaluation criteria and procedures for certifying green or sustainable architecture. Green technologies encompass a broad spectrum of technological innovations aimed at reducing the adverse impacts of human activities on the environment and fostering sustainable development strategies. The purpose of this paper is to cover the significance of sustainable construction, the materials used to construct sustainable buildings, building assessment methods, the role that green technologies play in sustainable development, and the difficulties associated with applying sustainable construction techniques.

Leonora Charlotte Malabi Eberhardt et. al. (2019) The building industry contributes to resource scarcity by consuming vast amounts of natural resources and produces in addition large amounts of waste, both contributing to a considerable portion of the environmental impacts induced by the demands of a growing world population. Manufacturing of most building materials require large amounts of material and energy resources. These materials are nevertheless either down-cycled or ends up as waste after demolition. Consequently, the building industry only manages to exploit an insignificant percentage of the building materials' inherent economic value and durability. Hence, the need for improved resource efficiency will increase parallel to the growing human demands to ensure that

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future needs. Circular economy principles can potentially facilitate minimising the aforementioned pending issues emanating from the building industry through recirculation of building materials

Janaine Fernanda Gaelzer Timm et. al. (2023) This review discusses the unsustainable nature of current production and consumption patterns, particularly in the civil construction sector. To address this, the circular economy model has been proposed as a solution, but the impact reduction of circular strategies (CS) is not well understood. Thus, aligning CS with ecodesign can help achieve sustainable development. We conducted a systematic review of studies on CS and ecodesign strategies (ES) in the built environment, which led us to identify 23 essential strategies, including reuse, recycling, design for disassembly, and design for life extension. This article expands on previous research by identifying 51 CS and ES, some of which are interconnected, and adopting one strategy may benefit another. The authors propose a framework based on the Plan-Do-Check-Act concept to support and manage trade-offs when selecting strategies and to facilitate a collaborative decision-making process. The framework can also help manage the effects of using these strategies on circularity and environmental, social, and economic performance, ultimately improving the construction sector's environmental performance.

Maria Ghufran et. al. (2024) A significant percentage of any nation's economy comes from the building industry, and its performance can impact overall economic growth and development. This paper aims to identify the similarities and differences between the construction sector (CS) of developed and developing economies in terms of size, growth, and contribution to the Gross domestic product (GDP) to understand the similarities and variances in the CS dynamics, trends, and challenges, and to inform policy decisions and investments through the literature review. The study also explores the factors that affect the CS's performance in both types of economies, such as government policies, market conditions, and technological advancements. This paper concludes that the CS in developed economies is more established and technologically advanced, but there is still significant room for growth in developing economies. Moreover, a framework is proposed that could assist developing nations in opting for the construction economy. Further, the review emphasizes the significance of government policies and investments in infrastructure development to stimulate the CS's growth and support overall economic development. The results of the study will assist in enhancing understanding of the CS's potential in both developed and developing economies and support decision-making for policymakers, industry practitioners, and academicians.

N. Andriyani et. al. (2024) The conventional disposal of demolition waste in landfills poses significant ecological harm. Integrating principles of the circular economy can help alleviate this impact by encouraging the reuse, recycling, and recovery of materials. This study presents a ground-breaking approach to demolition that aims to tackle the growing waste problem and bridge the existing regulatory loopholes. The framework leverages Building Information Modeling for Just-In-Time delivery and circular economy practices to prioritize environmentally friendly, efficient, and sustainable operations. The framework aims to transform demolition practices, reduce environmental impact, and promote sustainability within the construction sector by incorporating these principles.

Rabia Charef et. al. (2021) To facilitate the adoption of the circular economy (CE) in the architecture, engineering and construction (AEC) sector, some authors have demonstrated the potential of recent designs that take into account the sustainable management of an asset's end-of-life (EOL), providing an alternative to the dominant designs that end with demolition. However, there is no review of the literature that encompasses a large range of sustainable designs in the current CE context. This paper provides a critical review of journal papers that deal with the barriers to implementing sustainable designs and approaches to the EOL management of assets that have the potential to fulfil the principles of the CE. Eighteen approaches related to prefabrication, design for change, design for deconstruction, reverse logistics, waste management and closed-loop systems were found. Through an analysis of the barriers that are common among these 18 approaches, we classified them into six different categories (organisational, economical, technical, social, political and environmental). Two Sankey diagrams illustrate the interrelation between the barriers, their categories and the 18 approaches. The diagrams clearly show that most of the barriers are common to multiple approaches and that most of the barriers relate to organisational concerns. The study gives a detailed map of the barriers that would help stakeholders from the AEC sector develop strategies to overcome the current obstacles in the shift to a CE.

Ali Akbar Firoozi et. al. (2022) The construction industry is a major contributor to global resource consumption and environmental degradation, emphasizing the need for sustainable material management. This study explores the integration of circular economy (CE) principles into the construction sector to enhance resource efficiency, reduce

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waste, and promote the reuse and recycling of materials. We review current practices identify barriers to CE adoption, and propose innovative strategies such as modular design, material passports, and digital platforms for material tracking and exchange. The environmental, economic, and social benefits of adopting these principles are examined through detailed case studies of pioneering projects that showcase significant reductions in environmental impact, operational costs, and enhanced social value. The paper highlights the potential of CE to transform the construction industry towards sustainable practices that align with the Sustainable Development Goals (SDGs) on responsible consumption and production, and sustainable cities and communities. The study concludes by discussing the challenges and opportunities in mainstreaming circular economy practices within the industry, urging a collaborative approach among stakeholders for successful implementation.

III. FINDING

The study concludes by discussing the challenges and opportunities in mainstreaming circular economy practices within the industry, urging a collaborative approach among stakeholders for successful implementation. The need for improved resource efficiency will increase parallel to the growing human demands to ensure that future needs. Circular economy principles can potentially facilitate minimising the aforementioned pending issues emanating from the building industry through recirculation of building materials. This paper will tackle a research gap that academia and policymakers often highlighted, which is how can we apply CE to assets that are predominantly meant to be demolished and their resources wasted when they reach their end-of-life. Globally, the paradigm aims at erasing the waste concept, relying on renewable and regenerative sources, and keeping the materials, components, and systems in use at their highest value as long as possible

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