INTEGRATION OF CIRCULAR ECONOMY INTO DESIGN AND CONSTRUCTION OF INFRASTRUCTURE PROJECTS IN MALAYSIA: BARRIERS AND COUNTERMEASURES

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Abstract

Despite the high demands of infrastructures, circular economy (CE) is among the best solution that seeks holistic sustainability goals through a zero-waste culture and to boost economic growth by investing in eco-innovations, secondary raw materials, recycling processes, and industrial symbiosis. Therefore, this study aims to identify the barriers and countermeasures for integrating the CE concept into design and construction of infrastructure projects in Malaysia. For data collection, an open-ended interview has been carried out with twenty-three (23) respondents of clients, contractors, and consultants. Then, the thematic analysis was performed to analyse the data. The findings suggested that the main barriers of CE integration are consisted of internal and external factors; technical, organisational, economic, political, social and environmental aspects. Then, the countermeasures of CE integration are categorized into the hard and soft strategies; raising the awareness of CE, encouraging stakeholder's collaboration and creating financial incentives, and investment opportunities. As a result, the outcome of the findings can serve as a guideline for stakeholders to integrate CE concept into design and construction of infrastructure projects in order to achieve sustainability development goals (SDG). Through the outcome of this study, stakeholders will have a new approach and new paradigm, which will be useful for future decision-making on the infrastructure with the CE concept.

Keywords: Circular Economy, Design, Construction, Infrastructure, Barriers, Countermeasures

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INTRODUCTION

Malaysia experienced rapid urban population growth in the last nine decades, particularly during the 1980s and 1990s. The ethnic urban composition is particularly interesting, with over 50% of the population being Malay. The rapid socio-economic development has led to issues such as housing, health, education, and sanitation facilities. (Yaakob et al,.2010).

The high rates of urban growth, natural increase, migration into urban areas, and to some extent reclassifications of the urban areas have significantly contributed to urbanization in the country. In Malaysia, urbanization history ranges from the Straits settlement of Penang, Malacca, and Singapore and the mining towns of Ipoh and Kuala Lumpur. Infrastructure development plays a crucial role in economic growth, with affluent countries having better infrastructure, promoting agriculture, trade, industry, and commerce. In contrast, poor infrastructure hinders urbanization and socioeconomic development (Ng et al,. 2019). Malaysia experienced a fast pace of urbanization between 1990 and 2000, driven by rapid economic growth and transformation.

DOSM (2022) recorded that Malaysia's urbanization rate rose to 75.1 percent (24.4 million) in 2020, up from 70.9 percent (19.5 million) in 2010. Urbanization generated new economic activities and created more employment opportunities, as well as providing greater access to modern social facilities. In a linear economy, resources are extracted, goods are produced, and rubbish is discarded as waste. Malaysia, a country with a linear economy model, is now promoting circular economy principles and practices in various sectors, including manufacturing, waste management, and sustainable development.

The Malaysian government launched the National Policy on Industry 4.0 in 2019, emphasizing sustainable growth through advanced technologies and practices. A circular economy (CE) seeks to reduce waste, increase resource efficiency, and encourage ongoing material usage as opposed to the "take-make-dispose" approach, which creates waste. Utilising a closed-loop system, the "reduce-reuse-recycle" paradigm allows resources to circulate and be recycled. In conclusion, a circular economy emphasises reuse and recycling to minimise waste and maximise resources, whereas a linear economy takes a "throwaway" attitude.

CE is crucial due to the rapid growth in raw material demand and finite supplies. Malaysia, a fast-growing and developing country, faces pollution and sustainability issues due to its rapid industrial development. To transition towards CE, better product and packaging designs, collection, sorting systems, and recycling infrastructure are needed to reduce virgin material use and promote a circular waste path.

LITERATURE REVIEW
Overview of Infrastructure Projects

Infrastructure refers to the fundamental physical systems and structures that are crucial for the smooth functioning of a society or organization. These infrastructures comprise both public and private entities such as (1) transportation including of roads, railways, bridges, tunnels; (2) water supply and sewers including its system and treatment plant; (3) energy such power plant, electrical grids and renewable energy sources; (4) telecommunications for network communication, internet connectivity as well as broadband access, and (5) public facilities including of public buildings, schools, hospitals and any other essential facilities. Additionally, infrastructure encompasses services and facilities that cater to the needs of the economy, households, and businesses. It plays a vital role in promoting economic growth, preserving the environment, and ensuring social well-being.

Sustainable infrastructure is designed with the objective of minimizing its adverse effects on the environment, by lowering greenhouse gas emissions, conserving natural resources, and adopting sustainable construction and operation practices. Sustainable infrastructure initiatives are advantageous to nearby communities in numerous ways. They help to preserve natural resources, reduce the negative effects of climate change, provide better access to financial resources, enhance labour and community relations, and offer long-term benefits to present and future generations. Additionally, they improve water quality and quantity, as well as urban livability through the creation of green spaces and urban forests. Moreover, these projects enhance social cohesion and contribute to economic development.

Circular Economy in Infrastructure Projects

The promotion of sustainable infrastructure projects is being emphasized by ASEAN and Asia, backed by the ASEAN Connectivity Master Plan and the Asian Development Bank. These endeavors are geared towards fostering economic growth, preserving the environment, and promoting social welfare, necessitating extensive planning and cooperation. The nations that make up the ASEAN bloc are actively working together to advance sustainable infrastructure development through a number of key initiatives, such as Infrastructure Asia, MPAC 2025, ASEAN-ADB cooperation, and Public-Private Partnerships (PPPs). These collaborations are designed to improve connectivity, streamline project preparation, and boost infrastructure productivity, all while tapping into the private sector's expertise to speed up project implementation and meet sustainability targets (Taiwo et. al., 2021).

The construction sector in Asia is adopting circular economy approaches in order to minimize its global impact and preserve natural resources.

The adoption of circular economy practices is on the rise in the construction industry across Asia, as evidenced by instances such as waste recycling in India (Mistri et al.,2020; Jain et al,.2020; Parida et al,.2023), and circular models of construction in Asia. These practices are geared towards reducing global impacts and conserving natural resources. In Japan, the construction sector is taking steps to develop circular economy practices, identifying any obstacles and providing guidance for advancement (Beng & Matsumoto, 2012; Lacroix & Pioch, 2011; Liu et al., 2019). Kazakhstan's construction sector is also making strides in this direction, pinpointing opportunities and challenges (Tokbolat et al., 2020; Torgautov et al., 2021; Turkyilmaz et al., 2019). Taiwan's circular building design places emphasis on disassembly, material reuse, and recycling (Huang & Hsu, 2003; Ping Tserng et al., 2021; Yu et al., 2018). (Chutipat et al., 2023; Edyvean et al., 2023) explained that Thailand's Bio-Circular-Green Economy (BCG) model is a sustainable future model that incorporates circular economy principles. Malaysia is enhancing its infrastructure with projects like the MRT system in Kuala Lumpur, while also developing its technology and innovation sectors to fuel economic growth. On the whole, circular economy practices are gaining traction in the Asian construction industry with the objective of reducing global impacts and conserving natural resources.

Circular Economy in Malaysian Infrastructure Projects
The growing urbanization process in Malaysia requires proper infrastructure provision. Local governments have traditionally been responsible for building local infrastructure, but this approach has increased the financial load on the local government. To support the new growth centers and rapid population growth, further infrastructure development is necessary. The local government must find measures to motivate the private sector, particularly the private developers involved in significant development projects, to do so (Bina et al,.2008).

Malaysia has successfully carried out a number of sustainable infrastructure projects aimed at promoting sustainable development and reducing environmental impact. One of these projects is the Green Energy and Sustainable Water Infrastructure project, which is focused on developing sustainable water infrastructure and renewable energy sources. In addition to this, Malaysia has also implemented sustainable transport infrastructure projects such as the Mass Rapid Transit and Light Rail Transit, which have been instrumental in reducing traffic congestion and promoting sustainable urban mobility. Another notable initiative is the Green Building Index (GBI) certification system which has been effective in promoting sustainable building practices and renewable energy sources. Moreover, Malaysia has also implemented waste management infrastructure projects such as waste-to-energy facilities and sanitary landfills, which have contributed to reducing waste and promoting sustainable practices. Overall, these

projects are a testament to Malaysia's unwavering dedication to sustainable development and reducing its environmental impact.

A rising number of market participants recognize that limited resources are mostly a result of resource scarcity, which has generated major environmental concerns such as pollution, floods, smog, and so on. (Górecki et al., 2019). The Circular Economy (CE) is a concept in industrial and social evolution that seeks holistic sustainability goals through a zero-waste culture. It is based on concepts like "Waste Products," "Industrial Ecology," "Cradle to Cradle," "Performance Economy," and "Biomimicry." It entails restoring products and materials at the end-of-life stage, changing to renewable energy, eliminating harmful chemicals and waste, and maximizing competitive advantage through the superior design of materials, products, systems, and business models (De los Rios & Charnley, 2017).

Circular economy (CE) addresses climate change, biodiversity loss, waste, and pollution, benefiting businesses, the environment, and mankind. It is based on three principles: eliminating waste, circulating products and materials, and regenerating nature. CE has two main cycles: technical cycle, where products are reused, repair, remanufacture, and recycling, and biological cycle, where nutrients from biodegradable materials are returned to Earth through composting or anaerobic digestion (Salleh et. al., 2022). Figure 1 shows the difference between linear economy and circular economy.

Figure 1: Linear Economy versus Circular Economy
Source: Garcés-Ayerbe et al., (2019); Adams et al., (2017)

The Twelfth Malaysia Plan, announced by Prime Minister on 27 September 2021, outlines a five-year plan for waste management and transitioning to the CE. It includes developing policies, legislation, and economic instruments, reviewing eco-design requirements, introducing a new regulation on household e-waste, creating a comprehensive waste database, constructing integrated waste management facilities, reviewing existing legislation, promoting single-use products, and constructing integrated scheduled waste treatment and disposal facilities.

Knowledge Gap and Study Positioning
The majority (75%) of those involved in Malaysia's construction business are not familiar with the concept of Circular Economy (CE), according to survey results, and 90% of respondents said they are not prepared to implement such practices in the next five years (Siew, 2019). The CE can help create jobs and economic growth by investing in eco-innovations, secondary raw materials, recycling processes, and industrial symbiosis. Design for a circular economy aims to maintain product integrity and close loops while building economically viable product-service systems. Despite all the literature gathered related to circular economy in ASIA and especially Malaysia infrastructure, there are a few research questions arise: (1) what are the barriers of integrating circular economy into design and construction of infrastructure projects in Malaysia, and (2) what are the countermeasures of integrating circular economy into design and construction of infrastructure projects in Malaysia.

Therefore, the objective of this study will fill the gaps by (1) identifying the barriers of integrating circular economy into design and construction of infrastructure projects in Malaysia and, (2) identifying the countermeasures of integrating circular economy into design and construction of infrastructure projects in Malaysia.

RESEARCH METHODOLOGY
The data collection process entails gathering qualitative information from interviews with stakeholders ranging from the client or project owner, consultants and contractors. Thematic analysis is used to analyse the qualitative data collected.

Data Collection: Semi-Structure Interview
This study collects data on identifying the barriers and countermeasures for the integration of CE into design and construction of infrastructure projects in Malaysia from open-ended interviews via various methods including online survey (Google Docs), face to face and phone interview. Opara et al. (2021) found that Google Docs provides unique online, written interviews for qualitative

research, addressing time, budgetary, and geographical limitations in case studies. Online surveys provide control, flexibility, and accessibility for research participation (Braun et al,. 2021). As a result, stakeholders are purposely interviewed utilizing these methods in order to gain their unique viewpoints, practical knowledge, and experiences on the subject. The data was utilized for analysis and treated as anonymous.

A purposive sample technique was used, allowing researchers to select individuals who may give useful comments and information for data gathering. (Campbell et al., 2020) agreed that purposive sampling able to aims to match samples to research objectives, improving rigor, study rigor, and data trustworthiness.

This study's target respondents are mostly consisted of the stakeholders who are directly involved in the design and construction phases of the industry, particularly in infrastructure projects. These respondents are the industry stakeholders varying from the client/project owner, consultants and contractors. Figure 2 shows that most of the respondents have experience in infrastructure projects ranging from transportation, water, energy, waste, amenities and landscape.
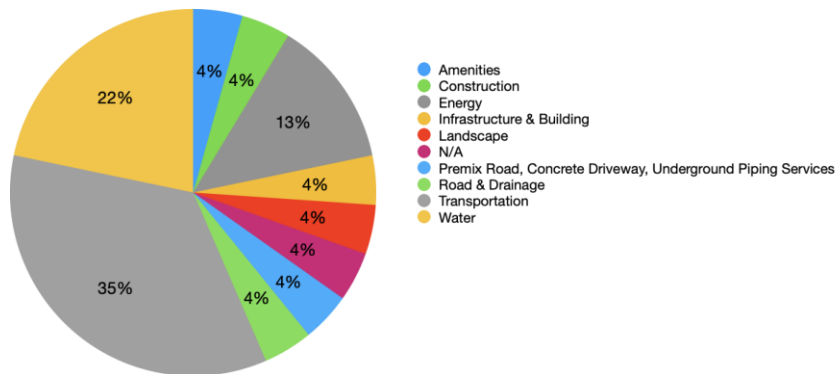
Figure 2: Type of Infrastructure Projects Involved by Respondents

The interview method collects statistically useful information about groups, requiring proper construction, ordering, scaling (Satya & Roopa, 2017). Through a systematic literature review, the design of the questionnaire must be carefully considered in order to collect usable and relevant information. The individual survey with interviews questions begins with an introduction to the topic, respondent demographic and an open-ended question questionnaire. In addition to that, question, the participants are given few introduction surveys such as their awareness on Circular Economy, current role or designation in the industry, working experience, education level and type of infrastructure that has

been involved. Then, additional open-ended questions depending on their responses. Satya & Roopa, (2017) suggested that questionnaires should always have a specific purpose that is relevant to the study objectives, and it should be clear from the beginning how the data will be used. This study's data collection involves interviewing twenty-three (23) respondents as portrayed in table 1.

Table 1: Respondents' Demographic

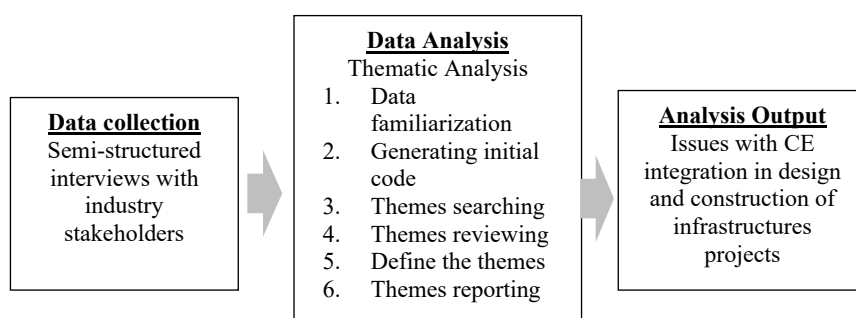| No of Respondent	Stakeholder	Current Position	Years of Industrial Experience
R1	Client/Project Owner	Executive	11-15
R2	Client/Project Owner	Project Manager	>16
R3	Client/Project Owner	Innovation Lead	11-15
R4	Client/Project Owner	Project Manager	6-10
R5	Contractor	Project Manager	11-15
R6	Consultant	Engineer	11-15
R7	Consultant	Architect	11-15
R8	Consultant	Engineer	6-10
R9	Client/Project Owner	Lead, Liaison	>16
R10	Consultant	Engineer	6-10
R11	Consultant	Town planner	6-10
R12	Client/Project Owner	Project Manager	>16
R13	Consultant	Engineer	6-10
R14	Contractor	Project Manager	6-10
R15	Client/Project Owner	Engineer	11-15
R16	Client/Project Owner	Project Manager	>16
R17	Contractor	Project Manager	>16
R18	Contractor	Project Manager	11-15
R19	Consultant	Project Manager	6-10
R20	Client/Project Owner	Project Manager	>16
R21	Client/Project Owner	Project Manager	>16
R22	Consultant	Quantity Surveyor	11-15
R23	Consultant	Engineer	>16

Data Analysis: Thematic Analysis
Thematic analysis is used to find patterns in interview data during data analysis. (Lester et al., 2020) agreed that thematic analysis is a flexible and user-friendly tool for qualitative analysis that helps researchers analyse data, uncover trends, and improve analytical abilities and confidence when performing qualitative research.

Figure 3 shows all the research techniques using thematic analysis to analyse the data collected from interview in this study. Thematic analysis detects patterns in qualitative data by going over it numerous times, categorizing it into themes, and interpreting it in the context of the research topic. (Nowell, Norris, White, & Moules, 2017) outlined the six-phased approach for undertaking theme analysis, which is an iterative and reflective process that evolves over time and

requires a continual back and forth between stages. First phase is to get familiarize with the data. This required reading and re-reading data to identify early trends and insights. The second phase is generating initial code. This stage will use codes to identify and label data in order to communicate meaning. The third phase is searching for themes which to collect and evaluate codes for themes in order to correctly represent data. In the fourth phase it will involves comparing the themes to the facts to verify they are consistent and relevant which is themes reviewing. While in fifth phase, the process requires the defining and naming the themes and the final phase is producing the report. This entails writing up the analysis, incorporating data quotations and examples to support the themes and findings.

Data collection Semi-structured interviews with industry stakeholders	**Data Analysis** Thematic Analysis 1. Data familiarization 2. Generating initial code 3. Themes searching 4. Themes reviewing 5. Define the themes 6. Themes reporting	**Analysis Output** Issues with CE integration in design and construction of infrastructures projects

Figure 3: Thematic Analysis Process

RESULT AND DISCUSSION
This study presents the findings of twenty-three (23) questionnaire interviews with clients/project owners, consultants, and contractors. The respondents are required to respond by identifying barriers and countermeasures for integrating CE into the design and construction of infrastructure projects in Malaysia. Based on the results, the findings suggested that the main barriers of CE integration are consisted of internal and external factors; technical, organisational, economic, political, social and environmental aspects. Then, the countermeasures of CE integration are categorized into the hard and soft strategies; raising the awareness of CE, encouraging stakeholder's collaboration and creating financial incentives, and investment opportunities. The details of themes and subthemes are discussed in the subsequent subsections.

Barriers for Integration of Circular Economy into Infrastructure Projects
Adoption of sustainable practices in infrastructure projects might be hampered by social, technical, environmental, economical and political reasons. Lack of

information, technical fragmentation, and reluctance to change are also social problems. Technical problems include the fragmentation of the Malaysian building business, a lack of experience, and a paucity of resources. Higher upfront expenses and expenditures are examples of economic issues, whereas regulatory and legislative hurdles are examples of political factors. Financial incentives, high initial costs, and market demand are all economic and political barriers that impede sustainable design (Charef et al., 2021). Collaboration and coordination among stakeholders are critical for implementation success. Figure 4 summarizes the themes and subthemes of problems the barriers.
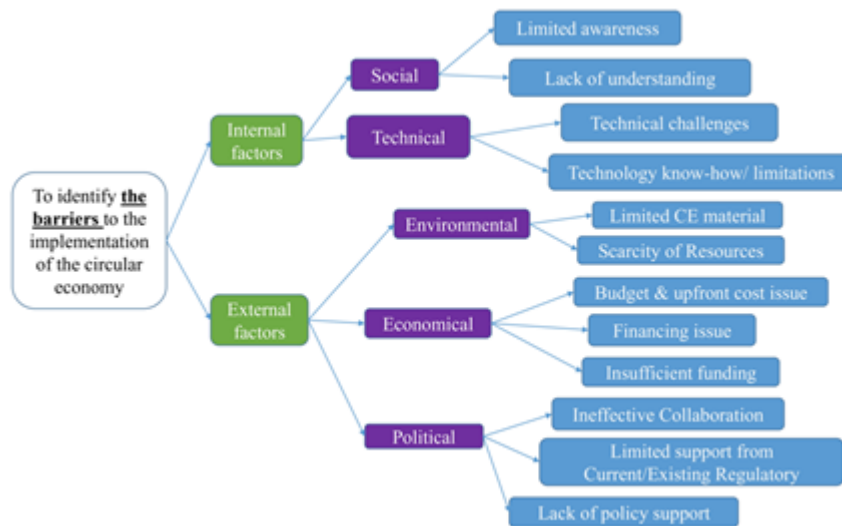

Figure 4: Internal and External Factors of Barriers for Integration of CE into Infrastructure Projects

Internal Factors

Social factors. The adoption of sustainable practices in infrastructure projects might be hampered by a lack of knowledge and comprehension of circular economy concepts among stakeholders such as designers, contractors, and government agencies. Construction professionals may be unfamiliar with these notions or are unaware of their potential advantages, which can lead to resistance to change and a reluctance to invest in new technology and procedures.

Technical factors. The Malaysian construction sector is fragmented, with many small businesses lacking the experience to embrace sustainable practices. This may impede the implementation of sustainable practices due to a lack of collaboration and knowledge-sharing among stakeholders. Resistance to change may also impede the adoption of sustainable practices in infrastructure

projects, since certain stakeholders may be resistant to new ideas or approaches, making it difficult to incorporate circular economy concepts into project design and construction.

External Factors

Environmental factors. The scarcity of resources such as recycled materials and renewable energy technology might make it difficult to integrate circular economy ideas in infrastructure projects. The scarcity of sustainable materials in Malaysia makes it difficult for developers and contractors to implement these principles into their projects. This is especially true in rural or distant places, where supply chains may be constrained, making circular economy ideas difficult to incorporate into infrastructure design and development.

Economical factors. Sustainable elements in infrastructure projects have the potential to raise building costs, affecting developers and contractors. Sustainable practices, on the other hand, can provide long-term advantages and savings. Implementing circular economy concepts may need greater investment or higher upfront expenditures, which may be prohibitively expensive for smaller construction enterprises or those with restricted budgets. Furthermore, the use of sustainable materials and technologies may be more expensive than traditional materials and technologies, making it challenging for designers and contractors working on limited budgets to embrace these practices.

Political factors. Adoption of sustainable practices in infrastructure projects might be hampered by regulatory and legislative obstacles. These hurdles might include favoring virgin resources over recycled materials, causing uncertainty, and restricting the use of specific sustainable materials or technologies. Governments play an important role in encouraging sustainable practices, but a lack of supportive legislation, rules, and guidelines may hinder their adoption. Furthermore, a lack of collaboration and coordination among parties such as designers, contractors, and government agencies might stymie the implementation of circular economy concepts in infrastructure projects.

Countermeasures for Integration of Circular Economy into Infrastructure Projects

The link between barriers and countermeasures entails ideas or actions to overcome possible barriers to incorporating circular economy concepts into civil infrastructure systems. These countermeasures are intended to assist effective integration and address the unique barriers that exist. Their efficiency is determined by their capacity to successfully handle the unique barriers that exist. The circular economy promotes sustainable infrastructure projects through policies, regulations, and lifecycle assessment. Figure 5 summarizes the themes and subthemes of problems the countermeasures.
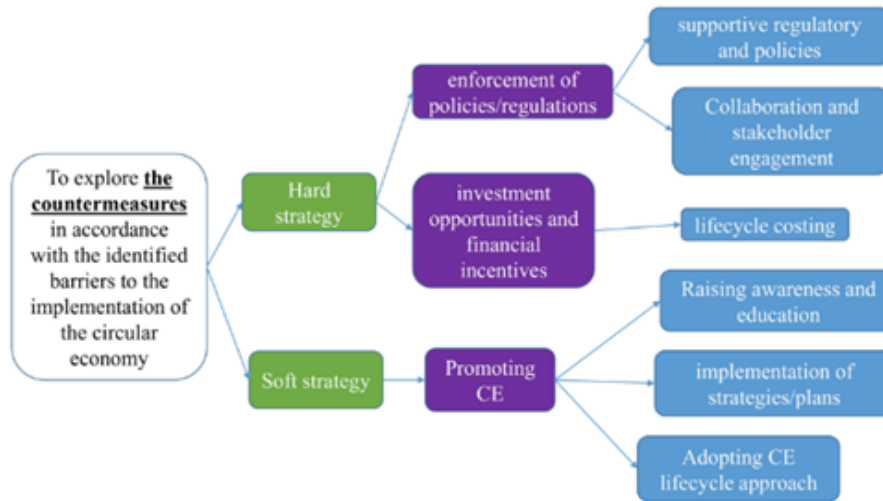
Figure 5: Hard and Soft Strategies of Countermeasures for Integration of CE into Infrastructure Projects

Hard Strategies

Enforcement of policies/regulations. Policies and regulations are critical for supporting the ideas of the circular economy in infrastructure projects. Setting resource efficiency objectives, developing sustainable material selection criteria, and offering financial incentives are examples of these. Green infrastructure, such as green roofs, rain gardens, and bioswales, may imitate natural systems while encouraging resource reuse. Collaboration and stakeholder involvement with suppliers, contractors, and local communities may raise knowledge of sustainable design and construction practices, helping to develop a more circular economy approach.

 Investment opportunities and financial incentives. A lifetime approach to infrastructure projects takes into account the whole lifespan of the project, from design to building, operation, and decommissioning. This method encourages circularity and reduces waste. Prioritizing environmentally friendly and sustainable items in procurement procedures is critical for encouraging sustainable materials and practices in infrastructure projects. Circular procurement practices priorities the use of sustainable and circular materials and goods, such as purchasing resources from suppliers who practice circular economy or reusing or recycling materials.

Soft Strategies
Promoting CE. Considering disassembly and recyclability when designing infrastructure projects means that materials and components may be easily separated and reused at the end of their lives. This method encourages the reuse and recycling of materials, components, and systems. A lifecycle approach to infrastructure projects takes into account the full lifecycle, from design to building, operation, and decommissioning. This method aids in the identification of waste reduction opportunities and promotes circularity. A lifecycle evaluation of infrastructure projects can help discover opportunities for resource efficiency and circularity, as well as evaluate the environmental impact of materials and design choices and the potential for reuse and recycling at the end of the project's lifespan.

STUDY IMPLICATION
This study's contribution will aid policymakers, other researchers, and industry practitioners in making decisions and improving existing standards.

Theoretical Implication
This study outlines challenges to incorporating CE in Malaysian infrastructure projects, as well as solutions and methodological issues. Few studies have used qualitative methodologies, and the majority have focused on building and building-related projects. Stakeholder preferences for incorporating CE into design and construction remain pessimistic. From an academic perspective, the thematic analysis presented in this study demonstrates barriers and countermeasures from the views of industry stakeholders, as well as information transfer or awareness challenges.

This study also examines the circular economy from stakeholders' perspectives, obtaining feedback and ideas. Results can be used to develop potential solutions for incorporating CE in Malaysian infrastructure projects design and construction. Furthermore, this study contributes to the investigation of areas that can broaden and enhance stakeholders' knowledge and awareness in order to conduct new strategies and paradigms for future discussion and decision-making on infrastructure design and construction utilizing the CE concept.

Practical Implication
From a practical perspective, this study's findings will benefit the construction industry. Stakeholders or industry practitioners might utilize the results to make early decisions on infrastructure development throughout the initiation and planning stages. Understanding CE ideas may help enhance infrastructure design while reducing environmental effect, maximising economic viability, and promoting social equality. This raises knowledge among senior management in

built-environment organisations, including developers, resulting in proactive decision-making and enhanced understanding of health, well-being, and productivity challenges.

Limitation and Future Directions
This study has identified barrier and countermeasures on the integration of CE in design and construction of infrastructure projects in Malaysia. The current study investigated and focuses more on identifying barriers and countermeasures only. Secondly, the inability of respondents from private companies to share elaborated internal data and the limited number of available stakeholders to conduct a questionnaire survey. Thirdly, majority of respondents were in middle management positions, which do not have full authority in decision-making stage. However, some of them do have the knowledge and awareness on CE and sustainability.

This study's limitations did not impact the quality of its findings, as the objectives were met. The findings can be applied in project initiation and planning stages for implementation. Despite a limited sample size of twenty-three respondents, the information was analysed with existing literature and saturation determined. More information from developers, consultants, contractors, and government representatives is required for future research and analysis, allowing for the actual application of findings in managerial contexts. Quantitative methods can also be used to evaluate the collected variables.

CONCLUSION
As a result, all the aims of study are achieved. Based on the findings from the interview, the results show that barriers to integrating the CE into design and construction of infrastructure in Malaysia are due to social, technical, environmental, economic, and political issues. Lack of awareness and comprehension of circular economy (CE) concepts, as well as technical problems and resource scarcity, can all hinder the application of these practices. Economic considerations such as greater upfront costs and limited budgets may also impede the adoption of CE concepts. While for the countermeasures to integrate the CE concept are including of enforcement of policies or regulations, more investment opportunities and financial incentives and promoting of CE in infrastructure projects. A lifecycle approach to infrastructure projects can discover waste reduction opportunities and encourage circularity. As a result, this study will serve as a guideline for stakeholders to include the CE idea in the design and construction of infrastructure projects in order to fulfil the SDGs. The findings of this study will provide stakeholders with a new strategy and paradigm for future discussion and decision-making on infrastructure design and construction using the CE idea. To integrate circular economy principles into Malaysia's

construction industry particularly for infrastructure works, stakeholders must work together to promote awareness, provide training, develop policies, and invest in waste management infrastructure.

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REFERENCES

Adams, K. T., Osmani, M., Thorpe, T., & Thornback, J. (2017). Circular economy in construction: Current awareness, challenges and enablers. *Proceedings of Institution of Civil Engineers: Waste and Resource Management*, *170*(1), 15–24. https://doi.org/10.1680/jwarm.16.00011

Beng, S. S., & Matsumoto, T. (2012). Survival analysis on bridges for modeling bridge replacement and evaluating bridge performance. *Structure and Infrastructure Engineering*, *8*(3), 251–268. https://doi.org/10.1080/15732471003594393

Bina, J. A., Salleh, D., & Siong, H. C. (2008). the Involvement of Private Sector in Local Infrastructure Development in. *Economic Policy*, (2), 73–100. https://www.researchgate.net/publication/45315541_The_involvement_of_privat e_sector_in_local_infrastructure_development_in_Malaysia

Braun, V., Clarke, V., Boulton, E., Davey, L., & McEvoy, C. (2021). The online survey as a qualitative research tool. *International Journal of Social Research Methodology*, *24*(6), 641–654. https://doi.org/10.1080/13645579.2020.1805550

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., … Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. *Journal of Research in Nursing*, *25*(8), 652–661. https://doi.org/10.1177/1744987120927206

Charef, R., Morel, J. C., & Rakhshan, K. (2021). Barriers to implementing the circular economy in the construction industry: A critical review. *Sustainability (Switzerland)*, *13*(23). https://doi.org/10.3390/su132312989

Chutipat, V., Sonsuphap, R., & Pintong, W. (2023). Bio-Circular-Green Model in a Developing Economy. *Corporate Governance and Organizational Behavior Review*, *7*(1), 150–157. https://doi.org/10.22495/cgobrv7i1p14

De los Rios, I. C., & Charnley, F. J. S. (2017). Skills and capabilities for a sustainable and circular economy: The changing role of design. *Journal of Cleaner Production*, *160*, 109–122. https://doi.org/10.1016/j.jclepro.2016.10.130

Durdyev, S., & Ismail, S. (2016). On-site construction productivity in Malaysian infrastructure projects. *Structural Survey*, *34*(4–5), 446–462. https://doi.org/10.1108/SS-12-2015-0058

Eberhardt, L. C. M., Birkved, M., & Birgisdottir, H. (2022). Building design and construction strategies for a circular economy. *Architectural Engineering and Design Management*, *18*(2), 93–113. https://doi.org/10.1080/17452007.2020.1781588

Edyvean, R. G. J., Apiwatanapiwat, W., Vaithanomsat, P., Boondaeng, A., Janchai, P., & Sophonthammaphat, S. (2023). The Bio-Circular Green Economy model in Thailand – A comparative review. *Agriculture and Natural Resources*, *57*(1), 51–64. https://doi.org/10.34044/j.anres.2023.57.1.06

Esa, M. R., Halog, A., & Rigamonti, L. (2017). Developing strategies for managing construction and demolition wastes in Malaysia based on the concept of circular economy. *Journal of Material Cycles and Waste Management*, *19*(3), 1144–1154.https://doi.org/10.1007/s10163-016-0516-x

Garcés-Ayerbe, C., Rivera-Torres, P., Suárez-Perales, I., & Hiz, D. I. L. D. La. (2019). Is it possible to change from a linear to a circular economy? An overview of opportunities and barriers for european small and medium-sized enterprise companies. *International Journal of Environmental Research and Public Health*, *16*(5).https://doi.org/10.3390/ijerph16050851

Górecki, J., Núñez-Cacho, P., Corpas-Iglesias, F. A., & Molina, V. (2019). How to convince players in construction market? Strategies for effective implementation of circular economy in construction sector. *Cogent Engineering*, *6*(1). https://doi.org/10.1080/23311916.2019.1690760

Huang, S. L., & Hsu, W. L. (2003). Materials flow analysis and emergy evaluation of Taipei's urban construction. *Landscape and Urban Planning*, *63*(2), 61–74. https://doi.org/10.1016/S0169-2046(02)00152-4

Ismail, S., Yusof, A., & Han, W. (2012). Elements of Relational Contract in the Delivery of Public Infrastructure in Malaysia. *IBIMA Business Review Journal*, *2012*, 1–11. https://doi.org/10.5171/2012.991384

Jain, S., Singhal, S., Jain, N. K., & Bhaskar, K. (2020). Construction and demolition waste recycling: Investigating the role of theory of planned behavior, institutional pressures and environmental consciousness. *Journal of Cleaner Production*, *263*, 121405. https://doi.org/10.1016/j.jclepro.2020.121405

Jemal, K. M., Kabzhassarova, M., Shaimkhanov, R., Dikhanbayeva, D., Turkyilmaz, A., Durdyev, S., & Karaca, F. (2023). Facilitating Circular Economy Strategies Using Digital Construction Tools: Framework Development. *Sustainability (Switzerland)*, *15*(1), 1–16.https://doi.org/10.3390/su15010877

Jin, X. H., Tan, H. C., Zuo, J., & Feng, Y. (2012). Exploring critical success factors for developing infrastructure projects in Malaysia - Main contractors' perspective. *International Journal of Construction Management*, *12*(3), 25–41. https://doi.org/10.1080/15623599.2012.10773193

Lacroix, D., & Pioch, S. (2011). The multi-use in wind farm projects: More conflicts or a win-win opportunity? *Aquatic Living Resources*, *24*(2), 129–135. https://doi.org/10.1051/alr/2011135

Lee, Z. P., Rahman, R. A., & Doh, S. I. (2020). Success Factors of Design-Build Public Sector Projects in Malaysia. *IOP Conference Series: Materials Science and Engineering*, *712*(1).https://doi.org/10.1088/1757-899X/712/1/012045

Lester, J. N., Cho, Y., & Lochmiller, C. R. (2020). Learning to Do Qualitative Data Analysis: A Starting Point. *Human Resource Development Review*, *19*(1), 94–106. https://doi.org/10.1177/1534484320903890

Liu, Chen, & Chou. (2019). Comparison of Assessment Systems for Green Building and Green Civil Infrastructure. *Sustainability*, *11*(7), 2117.

https://doi.org/10.3390/su11072117

Masrom, M. A. N., Rahim, M. H. I. A., Mohamed, S., Chen, G. K., & Yunus, R. (2015). Successful criteria for large infrastructure projects in Malaysia. *Procedia Engineering*, *125*, 143–149. https://doi.org/10.1016/j.proeng.2015.11.021

Mistri, A., Bhattacharyya, S. K., Dhami, N., Mukherjee, A., & Barai, S. V. (2020). A review on different treatment methods for enhancing the properties of recycled aggregates for sustainable construction materials. *Construction and Building Materials*, *233*, 117894. https://doi.org/10.1016/j.conbuildmat.2019.117894

Ng, C. P., Law, T. H., Jakarni, F. M., & Kulanthayan, S. (2019). Road infrastructure development and economic growth. *IOP Conference Series: Materials Science and Engineering*, *512*(1). https://doi.org/10.1088/1757-899X/512/1/012045

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis: Striving to Meet the Trustworthiness Criteria. *International Journal of Qualitative Methods*, *16*(1), 1–13. https://doi.org/10.1177/1609406917733847

Opara, V., Spangsdorf, S., & Ryan, M. K. (2021). Reflecting on the use of Google Docs for online interviews: Innovation in qualitative data collection. *Qualitative Research*. https://doi.org/10.1177/14687941211045192

Parida, R., Katiyar, R., & Rajhans, K. (2023). Identification and analysis of critical barriers for achieving sustainable development in India. *Journal of Modelling in Management*, *18*(3), 727–755. https://doi.org/10.1108/JM2-11-2020-0288

Ping Tserng, H., Chou, C. M., & Chang, Y. T. (2021). The key strategies to implement circular economy in building projects-a case study of Taiwan. *Sustainability (Switzerland)*, *13*(2), 1–17. https://doi.org/10.3390/su13020754

Radzi, A. R., Rahman, R. A., Doh, S. I., & Esa, M. (2020). Construction readiness parameters for highway projects. *IOP Conference Series: Materials Science and Engineering*, *712*(1). https://doi.org/10.1088/1757-899X/712/1/012029

Rahman, R. A., Radzi, A. R., Saad, M. S. H., & Doh, S. I. (2020). Factors affecting the success of highway construction projects: The case of Malaysia. *IOP Conference Series: Materials Science and Engineering*, *712*(1). https://doi.org/10.1088/1757-899X/712/1/012030

Salleh, H., Ying, C. K., Hanid, M., Samad, Z. A., Sabli, N. A. M., & Khuzzan, S. M. S. (2022). DEVELOPMENT OF GUIDANCE FOR THE ADOPTION OF CIRCULAR ECONOMY IN CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT. *PLANNING MALAYSIA*, *20*.

Satya, R. M., & Roopa, S. (2017). Questionnaire Designing for a Survey. *The Journal of Indian Orthodontic Society*, *46*(December), 273–277. Retrieved from https://www.researchgate.net/publication/235801675_Questionnaire_Designing_for_a_Survey

Siew, R. (2019). Are we ready for circular economy? Towards zero waste in construction. *Sustainable Buildings*.https://doi.org/10.1051/sbuild/2019002

Taiwo, O. M., Samsudin, S., & Ayodele, O. M. (2021). Integration of Sustainability Indicators in Urban Formation: A Gap Analysis. *Planning Malaysia*, *19*.

Tokbolat, S., Karaca, F., Durdyev, S., & Calay, R. K. (2020). Construction professionals' perspectives on drivers and barriers of sustainable construction. *Environment, Development and Sustainability*, *22*(5), 4361–4378. https://doi.org/10.1007/s10668-019-00388-3

Torgautov, B., Zhanabayev, A., Tleuken, A., Turkyilmaz, A., Mustafa, M., & Karaca, F. (2021). Circular economy: Challenges and opportunities in the construction sector of Kazakhstan. *Buildings*, *11*(11). https://doi.org/10.3390/buildings11110501

Turkyilmaz, A., Guney, M., Karaca, F., Bagdatkyzy, Z., Sandybayeva, A., & Sirenova, G. (2019). A comprehensive construction and demolition waste management model using PESTEL and 3R for construction companies operating in central Asia. *Sustainability (Switzerland)*, *11*(6). https://doi.org/10.3390/su11061593

Vaismoradi, M., Jones, J., Turunen, H., & Snelgrove, S. (2016). Theme development in qualitative content analysis and thematic analysis. *Journal of Nursing Education and Practice*, *6*(5). https://doi.org/10.5430/jnep.v6n5p100

Yaakob, U., Masron, T., & Masami, F. (2010). Ninety Years of Urbanization in Malaysia : A Geographical Investigation of Its Trends and Characteristics. *Journal of Ritsumeikan Social Sciences and Humanities*, *4*(3), 79–101. https://doi.org/10.1007/978-1-4020-4385-7_3

Yu, W. Der, Cheng, S. T., Ho, W. C., & Chang, Y. H. (2018). Measuring the sustainability of construction projects throughout their lifecycle: A Taiwan Lesson. *Sustainability (Switzerland)*, *10*(5). https://doi.org/10.3390/su10051523

Zainal, M. S. A., & Abas, Z. (2020). Adoption of Circular Economy for A Sustainable Solid Waste Management System in Malaysia. *Malaysian Management Journal*. https://doi.org/10.32890/mmj.22.2018.9670

Zamani, S. H., Rahman, R. A., Fauzi, M. A., & Yusof, L. M. (2021). Effect of COVID-19 on building construction projects: Impact and response mechanisms. *IOP Conference Series: Earth and Environmental Science*, *682*(1). https://doi.org/10.1088/1755-1315/682/1/012049