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THE ROLE OF THE QUANTITY SURVEYOR IN ACHIEVING CIRCULAR BUILT ENVIRONMENT AT THE DESIGN STAGE

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ABSTRACT

The construction industry is becoming more circular by reducing waste, reusing building materials, and embracing regenerative solutions for energy generation and biodiversity conservation. The ramifications of circularity on building operations are complicated, necessitating a comprehensive assessment of the consequences before deciding on the best course of action. In addition, professionals need to perform diversified services in achieving Circular Built Environment (CBE). Thus, the investigation of the involvement of Quantity Surveyors (QSs) with the CBE is important in achieving the CBE during the Design stage. Hence, the study aimed at investigating the role of QSs in achieving a CBE. The research apprehends a qualitative approach inclusive of two expert interview rounds adhering to the Delphi technique and manual content analysis for data analysis. The research findings revealed the important roles of QS in achieving CBE at the Design stage. Accordingly, cost control, cost planning, feasibility studies, measurement and quantification, risk management, value engineering and innovations and technologies were highly agreed upon by the majority of interviewees as important roles of QS during the Design stage.

Keywords: *Circular Built Environment (CBE); Design Stage; Important Roles; Quantity Surveyor (QS).*

1. INTRODUCTION

The Circular Economy (CE) is a philosophy that aims to alter current consumption and output trends that are putting a tremendous strain on the earth and its environmental capability (Spreafico and Landi, 2022). It has been extensively reviewed throughout the world as an alternative to the old economic model, namely, "purchase, consumption and dispose", as well as a solution to the complication of efficient use of resources and environmental pollution (Adi and Wibowo, 2020). The CBE is considered a key sector in CE where its strategies can be implemented (Egemose, et al., 2022).

CE in the built environment is easier to achieve (Stephan and Athanassiadis, 2018) by involving professionals to develop the incentive to create circular construction goods (Chang and Hsieh, 2019). Professionals in the built environment are now confronted with

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the difficult task of comprehending and transforming strategic sustainability goals into sound project-specific actions (Adams, et al., 2017). In addition, Buren et al. (2016) stated that professionals play a significant role in the CBE. Olanrewaju and Anahve (2015) have found architects, structural engineers, civil engineers, service engineers and quantity surveyors as the key professionals in construction projects. Professional Quantity Surveyor (QS) is a key domain of managing the cost of a project (Thayaparan, et al., 2011). Chamikara, et al. (2020) have defined a QS as a person who plays an expert role in the construction industry to uplift the sustainable approach. QS contributes greatly to adapting to those changes in CBE. Hence, it is important to investigate the QS's role in the sustainable development of the built environment (Yogeshwaran, et al., 2018). Among the seven stages of a building's life cycle (Foster, 2020), Design stage and Building Material Sourcing stage are considered the most crucial stages of the lifecycle of a building. The effectiveness and efficiency of the Design stage can significantly impact processes such as manufacturing that occur downstream in the product development process (Wijewansha, et al., 2021). Hence, this study aims to investigate the role of QS in achieving a CBE at the Design stage.

2. LITERATURE REVIEW

2.1 CIRCULAR BUILT ENVIRONMENT

CE is a way of replacing the end-of-life concept with an economic system that promotes resource reuse, alternately minimising, recovering, and recycling in construction distribution, production, and consuming processes (Kirchherr, et al., 2017). The popularisation of the concept of CE, along with the sustainability trend in the construction industry, motivate conducting studies on recycling and reusing waste streams included in the reprocessed aggregate (Geissdoerfer, et al., 2017). Furthermore, when building materials and components are no longer needed for the intended use, they are deemed as waste, hastening destructions to the ecosystem, increasing environmental costs, and generating resource scarcity. The construction industry is linked to demolition and end-of-life activities and operations. According to Nuñez-Cacho, et al. (2018), due to the high environmental impact of construction waste and demolitions, the construction industry needs to pay more attention towards optimising its resource consumption. The concept of CE can help mitigate the environmental impact of construction (Ghisellini, et al., 2018).

Construction professionals are the people who contribute to addressing the issue related to sustainable construction by designing, building, and operating facilities to create a sustainable built environment (Kibert, 2007). Thus, construction professionals play a pivotal role in achieving CBE. Among the many professionals, QSs play a significant role in making construction projects more feasible by utilising cost-effective ways while improving the worth of the final product (Chamikara, et al., 2020).

2.2 ROLES OF PROFESSIONAL QUANTITY SURVEYOR

Quantity surveying is a synthesis of several disciplines, including construction technology, computer technology, economics, law, and management, and many others (Panojan, et al., 2019). According to Dada and Jagboro (2015), the quantity surveying profession is no longer in its infancy. Several investigations and professional associations have explored the roles of QS in various ways. Table 1 illustrates the QS's roles which were identified from past studies.

Table 1: Roles of Quantity Surveyor identified by past studies

Roles of Quantity Surveyor	Researchers															
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
Measurement and quantification	✓	✓	✓		✓	✓		✓	✓		✓	✓	✓			✓
Cost control	✓	✓	✓	✓		✓			✓	✓		✓		✓	✓	✓
Cost planning	✓	✓	✓	✓	✓		✓		✓				✓	✓		
Preparation of Bills of Quantities (BOQ)	✓	✓	✓	✓	✓			✓		✓		✓	✓	✓		
Final account preparation	✓	✓		✓	✓		✓	✓			✓	✓	✓		✓	
Feasibility studies		✓		✓			✓	✓		✓	✓	✓			✓	✓
Risk management	✓			✓			✓	✓	✓	✓			✓			
Arbitration	✓		✓			✓				✓				✓		
Value engineering	✓		✓		✓	✓	✓			✓			✓		✓	✓
Interim valuations and payments	✓	✓	✓		✓	✓		✓		✓		✓			✓	
Cost estimation	✓		✓			✓			✓			✓			✓	
Preliminary estimation	✓	✓	✓	✓				✓		✓				✓		
Tender process	✓		✓	✓				✓		✓		✓		✓		✓
Procurement advice		✓	✓			✓			✓		✓		✓		✓	
Settlement of contractual claims	✓	✓				✓	✓		✓				✓			✓
Contract documentation	✓			✓		✓		✓			✓				✓	
Contract administration	✓	✓		✓			✓	✓		✓	✓				✓	
Value management					✓			✓	✓	✓			✓	✓	✓	
Facility management					✓	✓	✓									✓
Building information services	✓		✓			✓				✓			✓			✓
Specification preparation		✓	✓			✓			✓		✓					✓
Project management		✓			✓	✓			✓							✓
Construction planning		✓	✓	✓	✓	✓			✓					✓		
Variation analysis	✓		✓		✓		✓		✓							
Negotiations on financial issues			✓				✓						✓			
Quantity management	✓	✓				✓				✓						
Adjudication	✓		✓		✓					✓		✓		✓		✓
Subcontract administration	✓	✓						✓			✓				✓	
Technical auditing			✓		✓		✓					✓		✓		✓
Building surveying		✓		✓		✓			✓				✓			
Examine priced BOQs				✓		✓		✓			✓			✓		
Financial reporting	✓		✓				✓					✓				
Administration's maintenance	✓		✓						✓				✓		✓	
Meditation	✓			✓			✓				✓			✓		✓
Insurance evaluation		✓				✓				✓			✓			✓
Life cost analysis	✓		✓			✓			✓						✓	
Insurance valuation		✓		✓				✓			✓				✓	

Roles of Quantity Surveyor	Researchers															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Investment appraisal	✓			✓				✓			✓					✓
Programming		✓				✓				✓		✓				
Taxation advice			✓					✓					✓			
Due diligence reports		✓					✓		✓							✓
Premises audits				✓				✓				✓				
Insolvency services		✓					✓							✓		
Cost benefit analysis						✓					✓					✓
Private Finance Initiative (PFI) consultancy			✓										✓			
Cost modelling										✓			✓			
Post occupancy evaluation					✓	✓										
Planning and supervision			✓							✓				✓		
Sustainability advisor		✓						✓							✓	
Expert witness						✓										
Cost engineering services			✓				✓						✓			

A: Chandramohan, et al. (2018), B: Chamikara, et al. (2020), C: Yogeshwaran, et al. (2018), D: Salleh, et al. (2020), E: Olatunji, et al. (2010), F: Moyanga (2017), G: Wao and Flood (2016), H: Panojan, et al. (2019), I: Perera, et al. (2011), J: Thayaparan, et al. (2011), K: Pyung and Sungho (2018), L: Dada and Jagboro (2015), M: Oladotun and Edosa (2017), N: Olanrewaju and Anahve (2015), O: Shafiei and Said (2013), N: Sonson (2014), P: Xia, et al. (2016)

Due to the lack of literature findings specific to the roles of QS in CBE, literature findings related to the roles of QS in the built environment were extracted from the literature. According to Table 1, *'Measurement and quantification'*, *'Cost control'*, *'Cost planning'*, *'Bills of Quantities (BOQ)'*, *'Final account preparation'*, *'Feasibility studies'*, *'Risk management'*, are the roles of QS that were identified by the majority of the authors. Chamikara, et al. (2020) expressed that cost planning advises the client on how much the project cost will be. Also, cost planning will advise when the expected expenses will most possibly occur. Hence, it is important to get the required project finance and determine possible project profit. Therefore, the cost planning process is essential to the success of the project during the Design stage of the building. Furthermore, Yogeshwaran, et al. (2018) identified, '*Arbitration'*, *'Life cost analysis'*, *'Insurance valuation'*, *'Value engineering'*, *'Interim valuations and payments'*, *'Cost estimation'*, *'Preliminary estimation'*, *'Tender process'*, and *'Procurement advice'* as the key professional roles of a QS. According to Chamikara, et al. (2020), procurement advice is a key contractual role, and it helps enhance profitability by reducing superfluous expenses and minimise delays and speeding up the supply chain. Similarly, Rahla, et al. (2021) expressed that professionals and policymakers involved in the current practices related to the concept rarely take an innovative approach to ensure resource efficiency. The use of recycled products or forecasting recycling to the existing building stock does not comprehensively promote CE. The findings from the literature are in a generic form. However, the concept of CBE is far more different from the old linear growth model or linear economy of take, make, and discard of materials (Schroeder, et al., 2019). Thus, it is paramount to

investigate the roles a QS have to achieve CBE, specially during the Design stage, as the Design stage will lay the foundation for other stages of a building's life to evolve.

2.3 IMPORTANCE OF INVESTIGATING ROLES REQUIRED BY THE QUANTITY SURVEYOR IN ACHIEVING CIRCULAR BUILT ENVIRONMENT AT THE DESIGN STAGE

The global population is rapidly increasing, creating challenges to the entire natural system and human existence (Ortiz, et al., 2009). As a result, demand for residential buildings, commercial buildings, civil structures, and infrastructure will rapidly start to rise. According to Ahmed, et al. (2009), buildings use more than 15% of global materials. Also, the Design stage is arguably the most important in the CBE because the employer wants to ensure that every decision being made will maximise the employer's investment. Janssens, et al. (2021) further ascertained that, in the CBE, many professionals are expected to provide a diversified service. QS plays a significant role in sustainability (Chamikara, et al., 2020) and waste handling. Thus, the investigation of the flexibility of QS's role and adaptation in the presence of dynamic changes in the CBE is critical to the survival of the CBE and its resistance to threats. Unless QSs are not qualified to detect the future direction and be aware of impending changes as the CBE emerges, they will face more challenges than opportunities. Although the current diversified roles of QS has been widely discussed in the literature (Thayapaan, et al., 2011; Dada and Jagboro, 2015; Jaafar, et al., 2016; Moyanga 2017; Chandramohan, et al., 2018; Yogeshwaran, et al., 2018; Panojan, et al., 2019; Chamikara, et al., 2020), attention on QS's role in achieving CBE is rarely seen. Thus, conducting research regarding the role of the quantity surveyor in achieving a CBE at the Design stage is an absolute necessity.

3. METHODOLOGY

The Delphi technique is well-received method of getting expert opinions on a certain knowledge area (Mansour, et al., 2020). It aims to obtain a consensus among a panel of experts on real-world issues that are often intangible (Gad and Shane, 2012). The Delphi qualitative method was chosen as the research approach for this study. Experienced QSs were selected in two rounds of the Delphi survey using purposive sampling. Purposive sampling allows the selection of knowledgeable and interested interviewees in the selected area of study (Etikan, 2016). Chartered QSs with extensive expertise in the construction sector, especially connected to CBE practices, were regarded to have the necessary capability to make a judgment on the application CE concept. Therefore, experienced professionals representing construction organisations were invited for the study. In addition, PhD candidates with a primary focus on the circular built environment research domain were invited as respondents for the study. As an outcome, the type of sample plugs in the research gap with viral data and experience-based solutions. Therefore, the Delphi qualitative method can benchmark the roles of QSs (Avella, 2016). Table 2 provides the profiles of the participants for both Delphi rounds.

When selecting the purposive sample, as per the criteria given in above Table 2, every expert must fulfil the above compulsory qualifications, and at least two additional qualifications must be fulfilled. A total of twelve (12) experts participated for the first Delphi round, while ten (10) experts provided their contributions to the second Delphi round. Expert panels with panel size ranging from six to twelve are considered best for

Delphi studies (Habibi, et al., 2014); thus, the selected panel sizes during both rounds were considered appropriate.

Table 2: Expert profiles

Coding	Delphi Round 1	Delphi Round 2	Designation	Criteria						
				Compulsory Qualification				Additional Qualifications (Satisfy at least three)		
				C1	C2	Professional Experience (Satisfy at least one)		A1	A2	A3
						C3	C4			
I.01	✓	✓	Senior Lecturer	✓	✓	✓		✓	✓	✓
I.02	✓	✓	PhD Candidate	✓	✓		✓			✓
I.03	✓	✓	Chief QS	✓	✓	✓	✓		✓	✓
I.04	✓	✓	PhD Candidate	✓	✓		✓			✓
I.05	✓	✓	Managing Director	✓	✓	✓		✓	✓	✓
I.06	✓	✓	Senior Lecturer	✓	✓	✓		✓		✓
I.07	✓	✓	Senior Lecturer	✓	✓	✓		✓		✓
I.08	✓	✓	Managing Director	✓	✓	✓		✓	✓	✓
I.09	✓	✓	Chief QS	✓	✓	✓			✓	✓
I.10	✓	✓	Director	✓	✓	✓		✓	✓	✓
I.11	✓		Chief QS	✓	✓	✓		✓	✓	✓
I.12	✓		Managing Director	✓	✓	✓		✓	✓	✓

Compulsory Qualification: C1 - Graduate in Quantity Surveying Discipline, C2 - Knowledge and Better Understanding of CBE, C3 - More than 10 years in the Construction Industry, C4 - PhD Candidate in a related area.

Additional Qualifications: A1 - A Postgraduate degree related to Construction Management, A2 - Corporate Member of a Quantity Surveying Professional Institution, A3 - Practical Experience/ Research Experience in CBE

4. RESEARCH FINDINGS

4.1 DELPHI ROUND 1 - QUANTITY SURVEYOR'S IMPORTANT ROLES IN CIRCULAR BUILT ENVIRONMENT

The main objective of the expert interviews was to evaluate the applicability of literature findings related to the roles of QS that can be used to achieve CBE. Initially, through the literature review, fifty-two (52) QS roles in the built environment were identified. During the Delphi Round 1, the respondents were requested to validate the identified roles QS for CBE. QS roles with an agreement percentage exceeding 80% were considered as important roles. At the end of Delphi Round 1, twenty-nine (29) important roles were identified out of 52 QS roles. In addition, three (3) important new roles were identified and are indicated in bold letters. Hence, thirty-two (32) important roles in achieving the CBE were identified as illustrated in Figure 1 and carried forward to the Delphi Round 2.

During the Delphi Round 2, the same question was iterated by the respondents to build up a consensus.

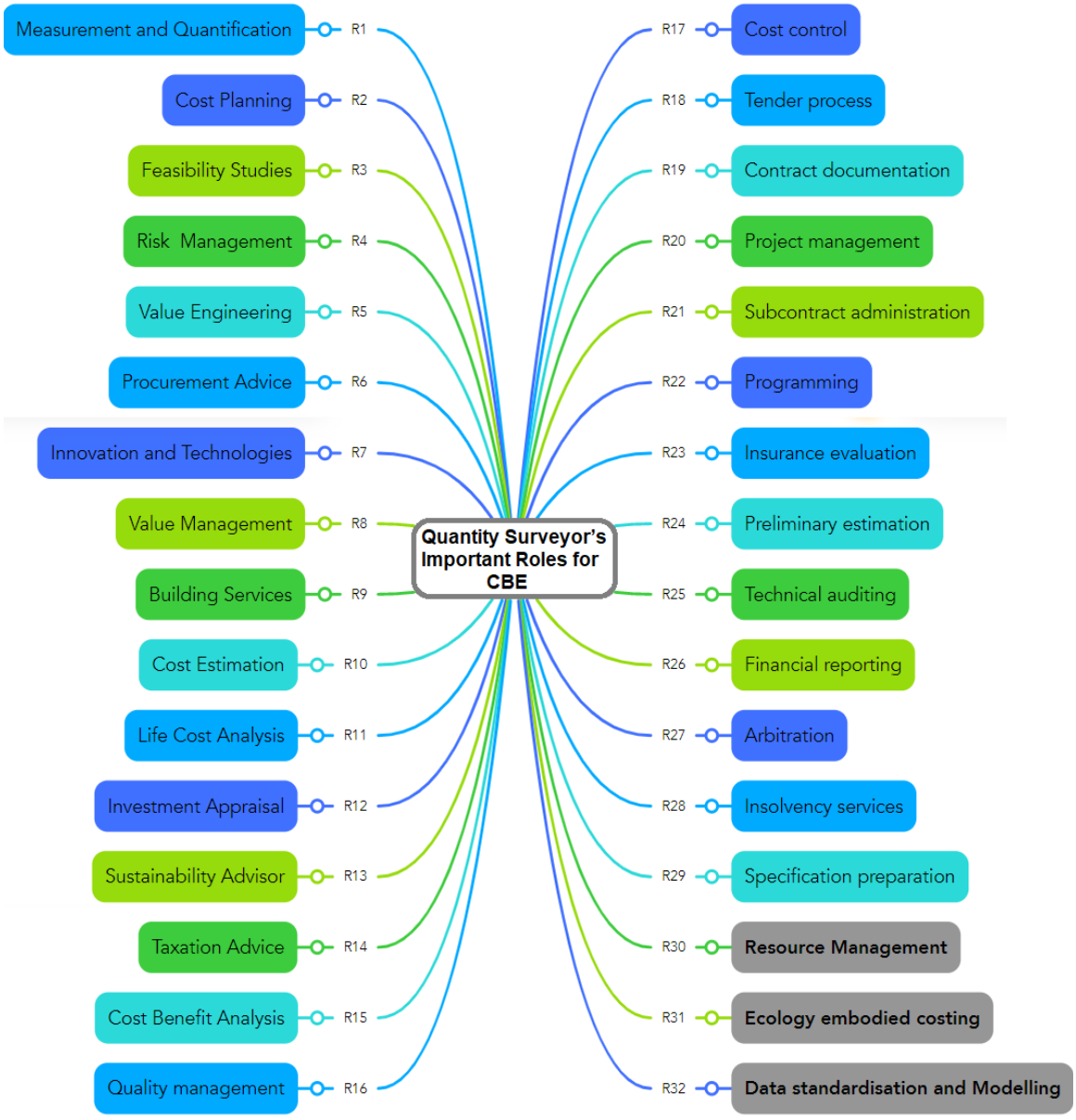

Figure 1: Quantity Surveyor's important roles for CBE

Figure 1 depicts QS's important roles that can be used in CBE as per the opinions of the respondents, and the roles are listed in descending order of their importance. The majority of respondents agreed that the QS's roles might be applied in CBE, as described in the literature. Specifically, **I.10** stated, *"The increasing rate of industrialisation has a negative influence on biodiversity all around the world."* As a result, there is an obvious and pressing need to lessen this impact by shifting away from linear consumption behaviour and toward more circular solutions, thereby minimising the footprint of the built environment. **I.10** especially highlighted, *"The construction industry and built environment have a tremendous impact on the environment since they are the greatest users of natural resources, accounting for more than a third of all energy consumed globally on an annual basis."* Moreover, **I.08** stated that *"The effects of circularity on*

building operations are complex, needing a detailed check of the consequences before deciding on the best course of action."

All the ten (10) interviewees agreed with the first four key roles of QS's in CBE, namely, *Cost control*, *Cost planning*, *Feasibility studies*, and *Risk management*. On the Value engineering, **I.09**, who objected to the factor, stated that *"When considering the usage of locally and culturally relevant materials, value engineering cannot have a substantial influence at the design stage."* Otherwise, all the participants implied the benefits in *Value engineering*, considering strategies of CBE such as enhanced efficiency in the built environment, prioritising what is important and easy recycling, achievement of Green Building certificate (LEED, BREEAM, DGNB), cost-savings in recyclable finishes and light fixtures, helps to deliver a smart building etc. Under the *Procurement advice* role, **I.10** responded as, *"Where the comprehensive engineering work is used to obtain bids for equipment and supplies, issue purchase orders, and negotiate CBE contracts."* According to **I.10**, the value management role is the same as the duty in Value engineering. Building services carried out also another QS's role that has more positive responses with the approach of CBE strategies. **I.07,** who objected to the role, stated that *"Building services is a type of professional engineering that aims to provide a safe and comfortable indoor environment while reducing a building's environmental impact."* Most of the interviewees have given their opinion as *"Quality control is crucial during the Design stage since it is the cornerstone of the CBE project's success."* Furthermore, quality control directly affects to enhance materials durability to extend the lifespan of a construction. Although, respondents have highlighted the use of sustainable approaches in CBE.

4.2 DELPHI ROUND 2 - QUANTITY SURVEYOR'S IMPORTANT ROLES AT THE DESIGN STAGE

During the Delphi Round 1, twenty-nine (29) roles were identified. During the Delphi Round 2 interviews, experts were asked to identify applicable important and moderate roles at the Design stage in achieving CBE. QS roles with an agreement percentage exceeding 80% were considered important. Thus, at the end of Delphi Round 2, twenty-two (22) important roles were identified out of 29 QS roles. Figure 2 indicates important QS roles at the Design stage in achieving CBE.

All the interviewees have agreed that new roles ensure efficiency and productivity in achieving CBE strategies. **I.03** highlighted, *"At the Design stage, cost planning and control should highly impact for reduction of construction waste and materials where the management of actual and forecast costs against that budget."* Also, all the interviewees strongly agreed about cost planning and cost control. According to **I.04**, *"Risk management is an effective QS's role at the Design stage when it is implemented systematically through reduction principle of CBE."* Since QS necessitated the use of a substantial amount of material resources as well as the participation of a number of professionals and institutions in the decision-making process throughout the life cycle of built buildings. **I.06** highlighted, *"Measurement and Quantification role is required by all reduction of construction waste and material usage involved in either the generation or utilisation of construction cost information during the Design stage."*

Measurement and quantification *role is well-established in the CBE at the Design stage, and their applications are well known, where the majority of respondents agreed with*

this role. ***I.03*** *highlighted,* "For these systems to work effectively, QS involved in measurement and quantification have to have special characteristics because accuracy can be one of the most important aspects to ensuring that a construction project runs smoothly." *At the Design stage, construction resource management is a complete process that comprises pre-emptive planned, scheduling, and controlling of enterprise-wide resources. It helps to accomplish every task with precision and meet the project objectives within time.* ***I.01*** *highlighted,* "Appropriate resource management keeps projects on schedule by satisfying management and resource expectations and maximizing resource utilisation from contract to contract." *Furthermore, all interviewees highly agreed that embodied energy and cost of construction of any building depend upon the consumption of resources, more specifically construction materials at the Design stage. Thus, an efficient design may lead to reuse in built environment cost and ecology embodied costing. Therefore, QS plays a significant role in CBE at the Design stage.*

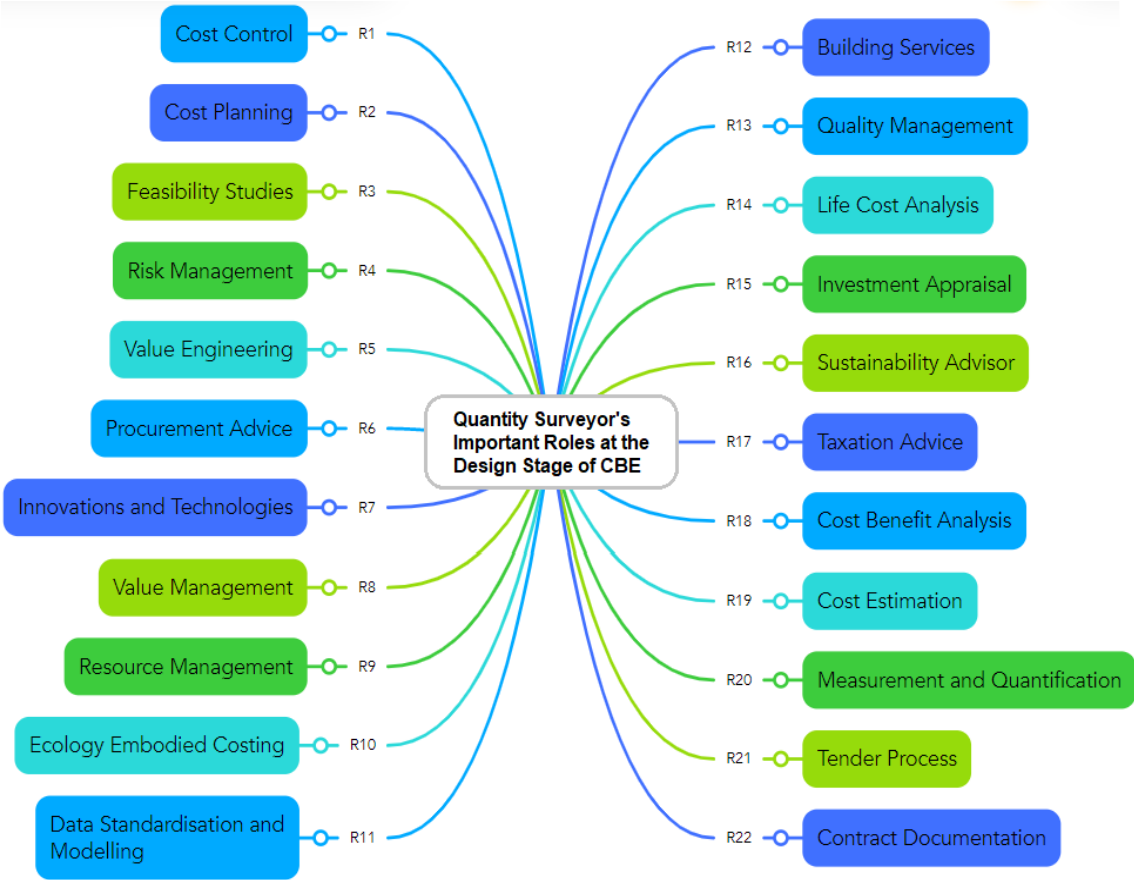

Figure 2: QS's important roles at the design stage of CBE

4.3 DISCUSSION

There are very few past research studies that discussed the use of CEB for a better future in the built environment. Among roles of a QS identified from the literature, most roles can be applied for in achieving CBE in the built environment. The most important roles are *'Cost control'* and *'Cost planning'*. Furthermore, **I.03** highlighted, *"At the Design stage, cost planning and control should highly impact to reduction of construction waste and materials where the management of actual and forecast costs against that budget."*

Hence, it is clear that cost control and cost planning roles cause more impact during the Design stage of CBE. Emphasising the impact of *'Cost control'* and *'Cost planning'*, Chandramohan, et al. (2020) had ranked these roles for QS context and highlighted that the cost control process involves ensuring that the budget does not exceed without prior client approval. Similarly, Chamikara, et al. (2020) expressed that cost planning gives advice to the client on how much the project cost will be. Also, cost planning will advise when the expected expenses will most possibly occur. Hence, it is important to get the required project finance and determine possible project profit. Therefore, the cost planning process is essential to the success of the project during the Design stage of the building.

Additionally, Panojan, et al. (2019) opined that risk management make construction projects more efficient and practical such that uncertainties should be identified before occurring and changing into crisis, and a balance should be made between threats and opportunities at the Design stage of building. Similarly, in this study risk management was identified as an important role a QS should play during the Design stage. Other than the above roles, Chamikara, et al. (2020) expressed that there are important roles such as *'Procurement advice'*, *'Value management'*, *'Sustainability advisor'*. Similarly, through this study, those roles were identified to be significant roles of QS in achieving CBE during the Design stage. According to Chamikara, et al. (2020), procurement advice is a key contractual role, and it helps enhance profitability by reducing superfluous expenses and minimising delays and speeding up the supply chain. Perera, et al. (2011) identified that the construction sector has contributed a lot towards the destruction of our ecosystem, with 32% of landfill waste are generated from the construction and demolition of buildings. 13% of construction waste is sent directly to the landfill without being used. Therefore, the sustainability advisor plays a vital role to provide consistency to the contract during the Design stage. When considering the literature findings, most of the previous research findings were based collectively on sustainability and QS job roles. Moreover, all the roles identified by the literature survey have been agreed upon by the respondents. Findings suggest that only the important roles have a certain degree of significance in CBE during the implementation at the Design stage of a building. In line with the research findings, many authors have stressed that the scope and design of the project may have a massive impact on the anticipated risk.

Furthermore, Chandramohan, et al. (2020) had ranked job diversity in quantity surveying in Sri Lanka, and the findings show a considerable similarity, where twenty-two of the important roles recorded in that study are recorded as diversified roles in this study as well. Conversely to this study, the authors have suggested the entrepreneur, PFI consultancy, and academics as important roles. Roles such as *'Resource management'*, *'Ecology embodied costing'*, and *'Data standardisation and modelling'* have not been addressed in previous studies related to QS's roles in the built environment. Nevertheless, with the research findings, **I.05** stated that *'Resource management'*, *'Ecology embodied costing'* and *'Data standardisation and modelling'* have a significant effect on the successful completion of CBE during the Design stage of building. Moreover, the impact of this study and probability values may vary with the project conditions and project nature.

5. CONCLUSIONS AND RECOMMENDATIONS

The aim of the study was achieved through a cumulative process consisting of a literature review and a two-round Delphi survey. The study was a cumulative process fulfilled through the literature review Delphi Rounds 1 and 2 of the expert interviews. The study was a cumulative process fulfilled through the literature review Delphi Rounds 1 and 2 of the expert interviews. 'Cost control,' 'Cost planning', 'Feasibility studies', 'Sustainability advisor', 'Risk management' and 'Value engineering', were strongly agreed QS's roles by interviewees in the Design stage of building in CBE. Furthermore, *'Cost modelling'*, and *'Innovations and technologies'* are also considered important roles that impact the QS role during the Design stage.

Among the recommendations advanced from this study, it is highly recommended to provide a clear and explicit scope definition during the Design stage of building. The newly identified QS's role, resource management, ecology embodied costing, and data standardization and modelling are recommended as new roles that QS should play to achieve circular CBE during the Design stage. Implementing the new technologies creates a need to prepare and implement proper regulations. For proper identification, monitoring and management of roles in the pre-construction stage of building, QS should understand the CE concept and an experienced project team are required.

This study will contribute to research by categorising QS's roles in achieving CBE, especially during the Design Sourcing stage of a building's life. Thus, this study can be used as a benchmark for future research when conducting further studies on different aspects of QS roles in CBE. The research finding help to upgrade the role of QSs to align with new trends in construction and can even be used as a curriculum for developing the QS related degree and diploma level programmes. Moreover, this research can be used as a formal guideline to achieve sustainable CE strategies to achieve CBE with the use of QSs. Lack of awareness of built environment professionals on the concept of CBE limits the number of participants for the study. Furthermore, with the COVID-19 pandemic situation, there were many difficulties contacting face to face potential participants for the study.

6. REFERENCES

Adams, K.T., Osmani, M., Thrope, T. and Thornback, J., 2017. Circular economy in construction: Current awareness, challenges and enablers. *Proceedings of the Institution of Civil Engineers - Waste and Resource Management,* 170(1), pp. 15-24.

Adi, W.T.J. and Wibowo, P., 2020. Application of circular economy in the Indonesia construction industry. *IOP Conference Series: Materials Science and Engineering,* 849(1), pp.1-8.

Ahmed, M.T., Saleh, M., Abdelkadir, A.F. and Abdelrehim, A., 2009. El Maghara scenario a search for sustainability and equity: An Egyptian case study. *Journal of Futures Studies,* 14(2). pp. 55-89.

Avella, J.R., 2016. Delphi panels: Research design, procedures, advantages, and challenges. International *Journal of Doctoral Studies,* 11, pp. 305-321.

Buren, N.V., Demmers, M., Heijden, R.V.D. and Witlox, F., 2016. Towards a circular economy: The role of Dutch logistics industries and governments. *Sustainability*, 8(7), pp. 2-17.

Chamikara, P.B.S., Perera, B.A.K.S. and Rodrigo, M.N.N., 2020. Competencies of the quantity surveyor in performing for sustainable construction. *International Journal of Construction Management,* 20(3), pp. 237-251.

Chandramohan, A., Perera, B.A.K.S. and Dewagoda, K.G., 2020. Diversification of professional quantity surveyors' roles in the construction industry: The skills and competencies required. International *Journal of Construction Management,* 22(7), pp. 1374-1381.

Chang, Y.T., and Hsieh, S.H., 2019. A Preliminary case study on circular economy in Taiwan's construction. *IOP Conference Series: Earth and Environmental Science,* 225, pp.1-8.

Dada, J.O. and Jagboro, G.O., 2015. Core skills requirement and competencies expected of quantity surveyors: perspectives from quantity surveyors, allied professionals and clients in Nigeria. *Construction Economics and Building,* 12(4), pp. 78-90.

Egemose, C.W., Bastien, D., Frette, X., Birkved, M. and Sohn, J.L., 2022. Human toxicological impacts in life cycle assessment of circular economy of the built environment: A case study of Denmark. *Buildings*, 12(2), pp. 1-19.

Etikan, I., 2016. Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics,* 5(1), pp. 1-4.

Foster, G., 2020. Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. *Resources, Conservation and Recycling,* 152, pp. 1-14.

Gad, G.M. and Shane, J.S., 2012. A delphi study on the effects of culture on the choice of dispute resolution methods in international construction contracts. In: *Construction Research Congress 2012,* West Lafayette, Indiana, United States: American Society of Civil Engineers, pp. 1-10.

Geissdoerfer, M., Savaget, P., Bocken, N.M.P. and Hultink, E.J., 2017. The circular economy - a new sustainability paradigm. *Journal of Cleaner Production,* 143(1), pp.757-768.

Ghisellini, P., Cialani, C., and Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114(15), pp.11–32.

Habibi, A., Sarafrazi, A., and Izadyar, S., 2014. Delphi technique theoretical framework in qualitative research. *The International Journal of Engineering and Science,* 3(4), pp.8-13.

Jaafar, M., Jalali, A., and Sini, N.M., 2015. Assessing the duties and competencies of female quantity surveyors. *Asian Social Science,* 12(1), pp.129-137.

Janssens, L., Kuppens, T. and Van Schoubroeck, S., 2021. Competences of the professional of the future in the circular economy: Evidence from the case of Limburg, Belgium. *Journal of Cleaner Production,* 281, pp.1-14.

Kibert, C.J., 2007. *Sustainable construction: green building design and delivery*. 5th ed. Hoboken: Wiley.

Kirchherr, J., Reike, D. and Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, pp. 221-232.

Mansour, H., AMinudin, E., Omar, B. and Al-Sarayreh, A., 2020. Development of an impact-on-performance index (IPI) for construction projects in Malaysia: A Delphi study. *International Journal of Construction Management,* pp. 1-10.

Moyanga, D.T., 2017. The perception of construction professionals to the use of quantity surveying research in Nigeria. *Civil and Environmental Research,* 9, pp. 17-23.

Nuñez-Cacho, P., Górecki, J., Molina-Moreno, V. and Corpas-Iglesias, F.A., 2018. What gets measured, gets done: Development of a circular economy measurement scale for building industry. *Sustainability*, 10(7), pp. 1-21.

Oladotun, A.J. and Edosa, O.M., 2017. The need for professionalism and competencies in the construction Industry'. *International Journal of Built Environment and Sustainability*, 4(1), pp. 10-16.

Olanrewaju, A. and Anahve, P.J., 2015. Duties and responsibilities of quantity surveyors in the procurement of building services engineering. *Procedia Engineering,* 123, pp. 352-360.

Olatunji, O.A., Sher, W. and Gu, N., 2010. Building information modeling and quantity surveying practice. *Emirates Journal for Engineering Research,* 15(1), pp. 67-70.

Ortiz, O., Castells, F. and Sonnemann, G., 2009. Sustainability in the construction industry: a review of recent developments based on LCA. *Construction and Building Materials,* 23(1), pp.28-39.

Panojan, P., Perera, B.A.K.S. and Dilakshan, R., 2019. Work-life balance of professional quantity surveyors engaged in the construction industry. *International Journal of Construction Management*, pp. 1-18.

Perera, P.S., Pearson, M.J., and Ekundayo, M.D., 2011. Mapping RICS quantity surveying competencies to curricula of RICS accredited programmes. In: *Proceedings of the 15th Pacific Association of Quantity Surveyors Congress,* Colombo, Sri Lanka, 23-26 July 2011, pp. 265-275.

Pyung, K., and Park K.S., 2016. Implication of quantity surveying practice in a BIM-enabled environment. pp.1-11.

Rahla, K.M., Mateus, R., and Bragança, L., 2021. Selection criteria for building materials and components in line with the circular economy principles in the built environment - A review of current trends. *Infrastructures*, 6(4), pp. 1-35.

Salleh, N.M., Husein, E., Husin, S.N., Muhammad, N.H. and Alang, N., 2020. Quantity surveyors' roles and responsibilities in different job sectors. *International Journal of Academic Research in Business and Social Sciences,* 10(10), pp. 1090-1101.

Schroeder, P., Anggraeni, K., and Weber, U., 2019. The relevance of circular economy practices to the sustainable development goals. *Journal of Industrial Ecology,* 23(1), pp. 77-95.

Shafiei, M.M. and Said, I., 2013. The competency requirements for quantity surveyors: Enhancing continuous professional development. *Sri Lankan Journal of Human Resource Management,* 2(1), pp. 17-27.

Sonson, S and Kulatunga, U., 2014. Quantity surveying role and environmental influence in Saint Lucia. In: *International Conference on Construction in a Changing World, CIB 2014 International Conference,* Heritance Kandalama, Sri Lanka, 4-7 May 2014.

Spreafico, C. and Landi, D., 2022. Using product design strategies to implement circular economy: Differences between students and professional designers. *Sustainability*, 14(3), pp. 1-19.

Stephan, A. and Athanassiadis, A., 2018. Towards a more circular construction sector: estimating and spatialising current and future non-structural material replacement flows to maintain urban building stocks. *Resources, Conservation and Recycling,* 129, pp. 248-262.

Thayaparan, M., Siriwardena, M., Amaratunga, D., Malalgoda, C. and Keraminiyage, K., 2011. Lifelong learning and the changing role of quantity surveying profession. In: *15th Pacific Association of Quantity Surveyors Congress*, Colombo, Sri Lanka, 23-26 July 2011, pp. 351-360

Wao, J.O. and Flood, I., 2016. The role of quantity surveyors in the international construction arena. *International Journal of Construction Management,* 16(2), pp. 126-137.

Wijewansha, A.S., Tennakoon, G.A., Waidyasekara, K.G.A.S. and Ekanayake, B.J, 2021. Implementation of circular economy principles during pre-construction stage: the case of Sri Lanka, *Built Environment Project and Asset Management,* pp.1-7.

Xia, B., Rosly, N., Wu, P.H., Bridge, A. and Pienaar, J., 2016. Improving sustainability literacy of future quantity surveyors. *Smart and Sustainable Built Environment,* 5(4), pp. 325-339.

Yogeshwaran, G., Perera, B.A.K.S. and Ariyachandra, M.R.M.F., 2018. Competencies expected of graduate quantity surveyors working in developing countries. *Journal of Financial Management of Property and Construction,* 23(2), pp. 202-220.