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Understanding the challenges of construction demolition waste management towards circular construction: Kuwait Stakeholder's perspective

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ABSTRACT

The built environment sector is under increasing pressure to reduce costs while improving environmental quality. This paper examines Kuwait's current construction and demolition waste (CDW) management policy, highlights the obstacles faced by recycling processes and suggests solutions to enhance waste management practices. Kuwait has only one landfill dedicated exclusively to CDW, operating since 2009. Even though Kuwait has facilities dedicated to handling and recycling CDW, recycling faces several obstacles that hinder its efficacy. This study aims to identify the impediments to efficient management practices through an extensive review of the literature followed by a questionnaire that was sent to 42 relevant stakeholders and interviews conducted with five stakeholders from the 1) Municipality of Kuwait, 2) the Ministry of Public Works, 3) the Environmental Public Authority, 4) the Kuwait Institute for Scientific Research, and 5) the Environment Preservation Industrial Company. This study concluded that present waste management procedures are inappropriate for achieving the circular construction concept and the 4 R framework (reduce, reuse, recycle and recover). Furthermore, it was found that raising the awareness of construction stakeholders and the public about waste management and recycling benefits is essential. This can be successfully implemented by emphasising recyclable products' economic and financial benefits. There is also a need to enforce Kuwait's existing environmental legislation and regulations to achieve a better CDW control framework. The outcomes of this study will assist decision-makers in establishing strategies to address the barriers to circular waste management practices in Kuwait and beyond.

1. Introduction

In recent decades, industry and researchers worldwide have become increasingly aware of the challenges presented by construction and demolition waste (CDW). Despite the construction industry's increased efforts to reduce the environmental impact of its processes, construction sites remain a significant source of pollution with a negative effect on the environment (Gangolells et al., 2014). According to Skoyles (Skoyles and Skoyles, 1987), CDW is a material or by-product of the construction process generated by non-conformity with specifications and non-use or excessive use of resources. The quantities of CDW generated are difficult to quantify because their composition varies and may include concrete, bricks, dirt, stones, plaster, wood, shingles, plumbing, and electrical parts. Globally, the CDW generated is around 35%, most of which is sent to landfills without being treated (Menegaki and Damigos, 2018). There are countries with alarming levels of landfill waste, above 40%, for example, Brazil (Saraiva et al., 2012) and Australia (Shen and Tam, 2002), while others, such as Canada (Yeheyis et al., 2013), Hong Kong (Lu and Tam, 2013) and the USA (Yu et al., 2013) tried to maintain their percentages below 30%. In the UK, construction waste formed 44% of the waste generated in 2013, and a half was disposed of in landfills. In 2014, the amount of CDW produced reached 58 million tons, then increased to 138 million tons in 2018 (Adams, 2018). Moreover, the European Union (EU) is attempting to move away from its traditional linear resource and waste management system toward a high level of circularity in the construction sector. The EU Waste Framework Directive has developed a new waste hierarchy paradigm based on the circular economy (CE) hypothesis. Gulf countries generate more than 120 million tons of waste yearly, 15% being construction waste (Shah et al., 2014). The amount of CDW produced in Kuwait between 2011 and 2020 is shown in Fig. 1.

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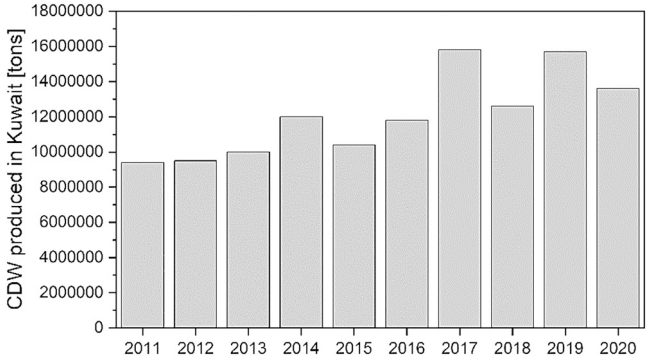

Fig. 1. Amount, in tons, of CDW produced in Kuwait between 2011 and 2020 (Kuwait population estimation, 2021).

The trajectory demonstrates an alarming upward trend, indicating the need for a new framework of CDW management because Kuwait has an area of 17,818 km^2 with an estimated population of 4464,521 (in 2020) (Kuwait population estimation, 2021). According to Gangolells et al., (2013, 2011, 2009), construction activities have a variety of negative impacts, including air and water pollution, soil alteration, consumption of resources, creation of local issues, transportation concerns, biodiversity effects and incidents, accidents and potential emergencies, as well as waste generation. As a result of poor waste management in the construction and demolition industry, a significant amount of waste is deposited in landfills (Albeeshi et al., 2017). Kuwait has only one CDW landfill, which has been operating since 2009. Despite that, 60–85% of CDW has been disposed of in all existing landfills in the last five years (as shown in Table 1) (Albeeshi et al., 2017).

The most recent data on Kuwait's waste statistics were produced in collaboration with the Kuwait Municipality, the Ministry of Health, and the Public Authority for Industry. The CDW that the Kuwait Municipality is receiving is a result of the demolition of buildings and facilities and is also material left over from the construction of new buildings and the rehabilitation and maintenance of existing structures. It consists primarily of sand, concrete, bricks, cement, and gravel. The construction industry needs to begin work immediately on reducing greenhouse gas emissions, the depletion of resources, and the consequences of climate change. There should be a focus on adopting a circular economic framework to ensure the long-term usability of construction materials (Hodge and Fitter, 2010; Sieffert et al., 2014). When these amounts are managed using effective methods, there will be considerable environmental and economic benefits, including a reduction in the amount of waste, a 50% saving in waste-handling costs, a 45% decrease in the amount of waste dumped into landfills, and a 15% reduction in the volume of waste produced prior to recycling (Shen and Tam, 2002). Additional benefits would include an enhanced public image of the construction industry, higher productivity, increased industrial security, and time-saving. This study indicated that 76% of waste in Kuwait could be recycled and would create an annual revenue of 137 million dollars from selling raw materials.

The significance of this study lies in its potential to: (1) quantitatively assess the amount of CDW in Kuwait, (2) identify the factors that contribute to the waste's environmental impact, and (3) examine the existing barriers to efficient CDW management in Kuwait. This study uses a mixed-method approach. It combines an extensive literature review with a questionnaire employed in order to: (1) understand the current practices and the strategies in CDW management for efficient and effective recycling, reuse, and recovery of resources; and (2) conduct interviews to assess the Kuwaiti construction industry stakeholders' awareness of circular practices.

2. Research methodology

The research was based on a qualitative mixed-methods approach that combined an extensive literature review with a survey conducted via questionnaire and interviews, as illustrated in Fig. 2. The questionnaire assessed the current practices in CDW management and investigated the strategies for efficient and effective recycling, reuse, and recovery of resources in Kuwait. The research questions were examined to achieve the core research objective, i.e., to understand current CDW management practices, guided by the survey method distributed in both the public and private sectors. The questionnaire asked participants about the recycled materials used in their projects and the obstacles facing CDW management practices and allowed them to express their thoughts about CDW. To ensure that the findings are reliable and representative and to avoid data saturation, the sample size formula was used. Forty-two questionnaires were sent out, and responses were received within a few days, indicating that Kuwaiti sectors, particularly the government, are aware of CDW and are prepared to address the problem. Participants were given a plain language statement authorised by Brunel University's ethics committee. The information gathered was to determine whether the aims and objectives of the CDW practices used in the construction and demolition of Kuwait projects have been met. This will also aid in detecting knowledge gaps among participants and knowledge gaps in the building and demolition sector, where weaknesses may be assessed for development. The interviews were formulated to be relevant to the various concerned stakeholders who control the performance of CDW in the Kuwait government, i.e., the municipality of Kuwait, the Government center for testing and quality control at the Ministry of Public Works, the Environmental Public Authority (EPA), and the Kuwait Institute for Scientific Research (KISR). Moreover, private waste recycling companies and the Environmental Preservation Industrial Company (EPIC) have only participated in the interviews without conducting the questionnaire to understand the relevant processes comprehensively.

2.1. Questionnaire and interview

A qualitative research study involving interviews and questionnaires to Kuwaiti stakeholders was conducted. The questionnaire consisted of three sections: (1) The purpose of Section A was to obtain the respondent's general opinions on CDW management, focusing on views on the existence of government directives and programs for CDW processing and sorting; (2) Section B dealt with the landfill process, the significant obstacles to promoting CDW management practices, and the potential for contract clause provisions that encourage and provide incentives for using recycled materials in new projects, and (3) Section

Table 1
Landfill sites operating in Kuwait municipality in 2020 (taken from the Kuwait government) (Kuwait population estimation, 2021).

Location	Area (million m^2)	The vicinity of the site (km)	Backfill materials	Year when work began on the site
Jahraa	1915	6.2	CDW / agricultural & non-hazardous industrial / commercial / household waste	1986
South seventh ring	5358	8.8	CDW + agricultural & non-hazardous industrial / commercial / household waste	1992
Mina Abdullah	2427	6.7	CDW / agricultural & non-hazardous industrial / commercial / household waste	1991
Erhia	-	-	Damaged tyres	2004
Construction and landfill waste	2250	6,0	CDW	2009

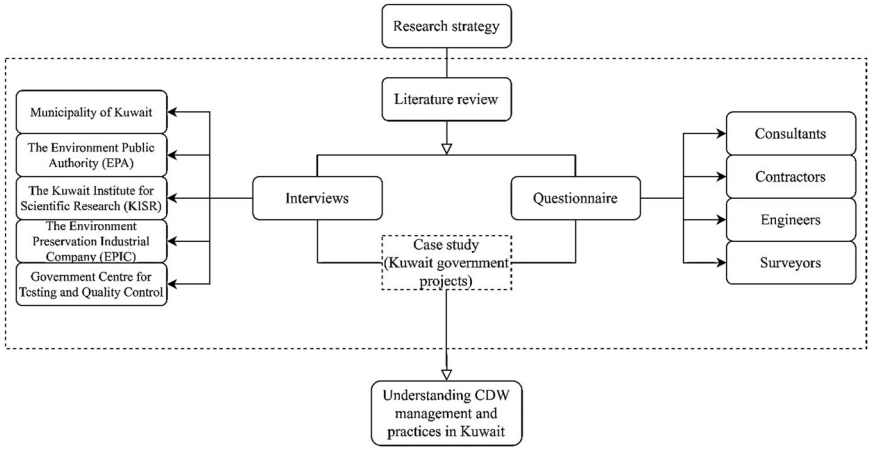

Fig. 2. Research strategy schematic.

Table 2
Organisations, titles, and years of work experience of the respondents.

Type of organization	Position of participants	Years of experience	Percentage of total participants
Engineer	Municipality engineering director Environmental manager Sustainability manager	10 +	70%
General contractor	Technical director	5–9	70%
Consultant	Senior H&S manager	10 +	30%
Surveyor	Engineer in the Ministry of Public Works	2–4	30%

C investigated circular loop construction and the CE and contained detailed questions regarding demolition and current CDW management practices. The details of those who participated in the study and their organizations are listed in Table 2.

3. Results and discussion

3.1. Evaluating the awareness of current CDW methods in the Kuwaiti construction industry

This section addresses concerns about the current policies and practices of the Kuwaiti's construction industry. It also includes responses to questions on how satisfied participants are with new decisions and current recycling procedures. Table 3 represents data from the questionnaire related to Kuwait's CDW management practices from selected stakeholders' perspectives.

CDW management satisfaction in Kuwait generated a range of responses among the participants in this survey. For example, an environmental manager engineer stated that "*recycling and utilizing waste will reduce the volume of waste in landfills.*" They expressed their dissatisfaction with the amount of waste dumped in landfills and emphasized the importance of recycling waste. When the participants were asked if they were satisfied with the current landfill process, 69% answered "No," while 31% answered "Yes." This result indicates that public engineers are generally aware of recycling and the amount of waste dumped in landfills. The participants' responses make sense in light of Table 4, which shows the enormous amounts of CDW dumped into landfill sites.

When participants were asked if they believed that the Kuwaiti government plays an active part in the waste treatment process, 60% answered "Yes" and 40% answered "No." The participants who answered "Yes" contributed exciting comments reflecting their concern about the waste treatment process. For example, it was stated that, in April 2021, the Kuwait Municipality and two private companies signed two memoranda of cooperation for one year and anticipated a future application of sound and integrated management. The agreement included exchanging information, statistical data, and plans to study a project to produce derived fuels. Another plan was for the extraction of

Table 3
CDW management-related issues in the Kuwait construction industry.

Item	Percentage selecting each option	
	Yes	No
Are you satisfied with the current landfill process in the construction industry?	31	69
Do you believe Kuwait's government plays an active part in the waste treatment process?	60	40
Do you think the Kuwaiti government made the right decision by obliging contractors to provide containers to separate the Construction and Demolition Waste (CDW)?	90	10
Are you applying waste sorting identification on the site?	95	5
Should there be a contract clause that requires the contractor to use recycled materials?	96	4
In your experience, have you observed that a policy of recycling materials has been implemented in the construction industry?	61	39
Do you think Kuwait's private sector is encouraged by incentives for recycling CDW?	77	23

Table 4
Recovery rates for Kuwait (taken from the Kuwait government) (Kuwait population estimation, 2021).

Quarters	Months	CDW received by recycling plant (tons) All the values × 10^3			CDW received to landfill sites (tons) All the values × 10^3		
		2018	2019	2020	2018	2019	2020
Q1	Jan	93	188	513	1067	966	1149
	Feb	169	153	435	1338	737	1170
	Mar	230	201	204	377	837	1120
Q2	Apr	193	183	1102	985	920	478
	May	143	222	33	1014	1042	253
	Jun	128	235	69	723	927	518
Q3	Jul	75	380	104	796	1097	854
	Aug	67	453	143	939	993	1075
	Sep	57	433	202	933	1219	1183
Q4	Oct	78	333	243	1014	1273	1254
	Nov	91	439	183	1030	1037	1201
	Dec	90	524	209	1043	945	1016
Total		1418	3744	2440	1261	11,999	11,275

petroleum products from waste plastic. Field visits to landfill sites and coordination with the competent authorities to conduct the necessary studies. At the same time, Bao et al. (2021) reported that several small-scale recycling centers had been constructed in China to manage the waste generated by renovation projects, particularly in Kunshan. All renovation waste is transported to these facilities for processing, including sorting, grinding, and recycling. Inert and light waste, wood, metal, and hazardous waste are separated into several categories. Circular construction can reduce the environmental impact by reducing CO_2 emissions and the amount of manufacturing and construction materials used. There has been worldwide recognition of the need for immediate action on the part of the construction sector to tackle climate change and reduce greenhouse gas emissions and the depletion of resources, with emphasis on the application of the CE method to ensure that construction materials are sustainably used (Ghaffar et al., 2020; Ghaffar et al., 2022). Since 2020, the EU has been applying new standards for buildings, and it is now required that a building in use is to be energy neutral.

Nevertheless, further reduction in damage to the environment can be achieved through the use of sustainable construction processes and materials. Additionally, in the survey, when asked whether the Kuwait government had made the right decision by obliging the contractor to provide a container to separate CDW, 90% of the participants agreed. The engineering director at the Ministry of Public Works, responsible for government CDW projects in Kuwait, stated that "*the Ministry's Safety Department will ensure the provision of the containers that the Kuwait Municipality has obliged project contractors to use in cooperation with project engineers. These containers are for the collection of construction waste. Then there are private companies that transport, dispose and treat the waste that falls within their jurisdiction according to the applicable regulations. Thesepanies will benefit from re-managing it in a manner that protects the environment and reduces the area of land used for landfills*". For example, the new airport project of the Kuwaiti Ministry of Public Works obliged the contractor (Limak, a Turkish company) to provide containers to separate construction waste. It is evident that most engineers are satisfied with the current decision. The few respondents who were unsatisfied with the decision were mainly contractors. The participants were asked whether they applied waste sorting identification on-site during the demolition and construction process: 95% answered "Yes," and only 5% answered "No." The participants' answers indicate that most engineers encourage smart dismantling on-site because it is the first step to achieving efficient treatment of CDW. They also favor the smart reuse of material. Additionally, CDW sorting systems can provide various flows with more uniform components to satisfy specific reuse or recycling requirements.

The participants were asked for their observations on recycled materials used in the construction industry. This question was posed to compare the quality of raw resources and utilized materials in construction projects. The respondents' answers were surprising: 61% noted that companies and corporations employed high-quality recycling of 50 items in their projects. As a result of these policies, companies' image, visibility, and CDW recycling statistics will improve. Furthermore, most respondents (77%) agreed that incentives encourage CDW recycling, and 23% said that the private sector does not receive enough incentives to recycle CDW. They believed that they would be more motivated if they received more recognition. Recognizing and rewarding the private sector would be a powerful means of motivating industrial stakeholders to recycle. The construction industry is competitive, and most enterprises strive against one another to be at the forefront. For example, the most extensively used green building rating system globally is LEED (Leadership in Energy and Environmental Design). LEED provides a framework for healthful, highly efficient, and cost-effective green buildings that can be applied to practically all building types. A new airport in Kuwait, a mega project developed by the Turkish company Limak, aspires to be one of the world's first LEED Gold-certified airports.

3.2. The barriers to implementing circular CDW management practices in Kuwait

The waste hierarchy prioritizes the prevention of waste from being created in the first place (Bao et al., 2021). When waste is generated, it is prioritized for reuse, recycling, or alternative recovery (such as energy recovery) and disposal (landfill after pre-treatment). The CE is defined differently and based on a sustainability strategy that aims to make the construction industry more environmentally friendly. CE technologies extend product life and almost eliminate waste entirely (Smol et al., 2015). The continual use of materials is critical for a successful CE (Akanbi et al., 2020).

Fig. 3(A) presents the survey results, which evaluate impediments to efficient CDW management and the significant obstacles to promoting CDW management practices in Kuwait. Of the respondents, 32% believe recycled materials have cost and quality difficulties. This is reasonable, as the price is a significant concern for all stakeholders in construction projects, and it is essential to retain and satisfy clients within a limited budget (Yuan et al., 2011). One of the most significant financial barriers is that waste producers refuse to engage in waste management procedures because they think it will increase project costs. Moreover, the engineers who work in the recycling factory stated in the interview that they faced a reduction in business when selling products resulting from

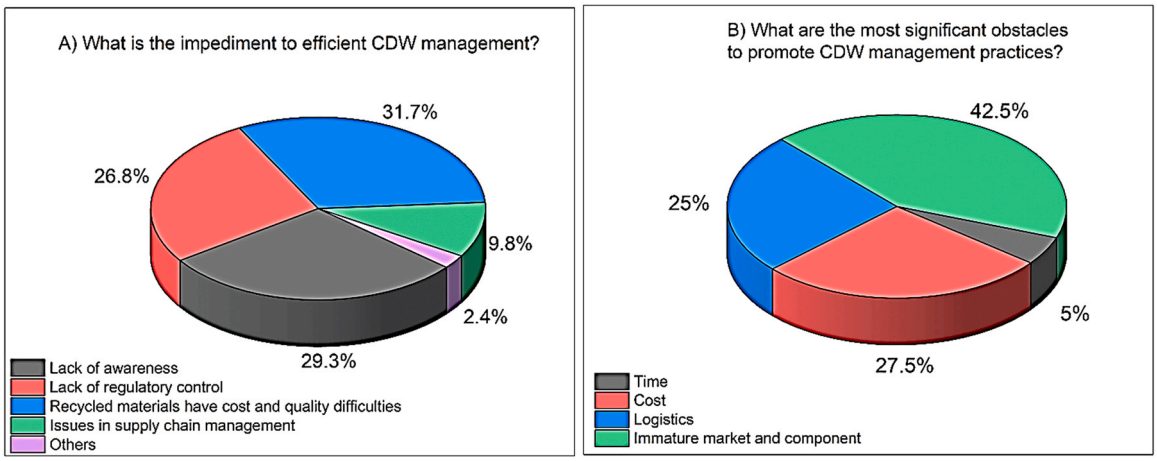

Fig. 3. The barriers to implementing CDW practices in Kuwait as revealed in the questionnaire survey.

the recycling of construction waste and that there was a lack of interest on the part of investors and the beneficiaries of its services. The findings reveal a lack of awareness in CDW management: 29% of those in CWD management were found to be either unaware of or not concerned by the environmental impact of CDW generation. This raises serious issues regarding awareness. Everyone working in the construction industry should be informed about the current situation and its significant environmental impacts. They should be encouraged to work environmentally friendly by sorting and segregating materials to reduce waste generation. The third obstacle, according to 27% of those questioned, is the lack of regulatory control of the numerous government projects in the country, along with a scarcity of professional engineers who have the experience to control the project situation (Agamuthu, 2008). Construction waste reduction strategies are enhanced when a legal framework covers environmental rules and recycling obligations. Many developed economies, including those of Finland, Germany, Australia, and Denmark, have legal regulations encouraging CDW management strategies, such as reduce, reuse, and recycle (Negash et al., 2021). Improvements in the regulatory system, social awareness, technical practices, and waste infrastructure development employing innovative treatment methods are needed to meet sustainable waste management in construction (SWM) goals. It was found that 10% of the participants were concerned about supply chain management issues. This finding is unsurprising, as Kuwait is a relatively small country with an area of 17,818 km^2. However, supply chain management is critical because an optimized supply network results in lower costs and a shorter production cycle. This was emphasized by an interviewee who has been working at EPIC for more than 20 years. They stated that the recycling factory faces a problem due to some contractors covering the construction waste with a layer of sand. Although it is recyclable, this waste is discharged into the landfills of the Kuwait Municipality instead of being supplied to the recycling factory. This is done to avoid payment of fees for transporting and providing construction waste to the factory, making it difficult to know the actual waste quantity, resulting in a shortage of recyclable raw materials and severe environmental damage.

As illustrated in Fig. 3(B), 43% of participants think the immaturity of the market and its components is the main obstacle to promoting CDW management practices. This result is consistent with the literature review (Shooshtarian et al., 2020). There are five market sub-barriers: 1) the lack of an established market for reused construction materials; 2) limited demand for second-hand building materials; 3) negative stakeholder attitudes and behavior; 4) costs being higher than alternative disposal methods; and 5) contractors who pay little attention to CDW reduction, resulting in irresponsible behavior. Yuan et al. (2011) noted that recycling requires a strong marketing strategy to identify markets and sell materials at the maximum realizable prices. In Kuwait, it is critical to recognize that the recycled product market can only grow if the government expands its national standards and regulations for materials to fulfill recycled material specifications without compromising the quality and strength of the finished products (Albeeshi et al., 2017). However, in an interview with the Municipality Director, it was indicated that coordination between the Ministry of Public Works and the Public Authority for Industry would be established to develop new uses for recycled products and to secure their marketing, thus protecting the environment and minimizing the amount of land used to dispose of this type of waste.

Meanwhile, 28% of the participants believe that costs are a significant obstacle to maintaining client satisfaction within a limited budget. All construction industry stakeholders are interested in saving money (Shooshtarian et al., 2020). Furthermore, the major impediment to adopting sustainable practices is high economic uncertainty; for example, the recycling process is costly in relation to the value of the recovered product. The most common barriers are the cost and time associated with sorting and recycling CDW and the availability and low price of virgin raw materials (Negash et al., 2021). Moreover, Planning to reuse building materials is often challenging due to the limited time for building demolition and materials recovery (Akanbi et al., 2019). In an interview with a scientific advisor to the construction and materials program of the Energy and Building Research Centre working at the KISR, it was claimed that the government of Kuwait restricts the extraction of natural quarried rubble (such as clay) for use in construction, with the result that it is not always available and is extremely expensive to buy on the open market. The feasibility of employing local materials to meet the needs of people in charge of building construction was investigated. During the research, the researchers devised a process for turning waste from washing sand – a by-product of concrete manufacturing – into a lightweight synthetic aggregate, from which lightweight concrete, bricks, and paving stones can be made. The study also found that the new technology has a favorable environmental impact, as it allows the reuse of various waste streams.

A quarter of the participants viewed logistics as a barrier to promoting CDW management practices. A well-designed recycling network that analyses the best locations, numbers, and expansion plans for treatment plants is critical for increasing CDW recycling rates (Esa et al., 2017). For example, an engineer working at EPIC says that in Kuwait recently, the kabd waste recycling center has had a very high pollution rate, threatening employees' health. This was due to the closure of the only road extending from the seventh ring road and leading to the construction waste plant where the CDW was recycled. No alternative road was provided, which led to severe damage to the company, as shown in Fig. 4. This procedure resulted in: (1) disruption of the transfer of construction waste to the two recycling projects by the

Fig. 4. The dirt road is the biggest obstacle to reaching the center (Al-jasem, 2021).

carrier companies; (2) disruption of the work of the recycling project, causing severe material damage to the company; and (3) disruption of the sale of products resulting from difficulties in recycling. In addition to that mentioned above, there will be environmental damage if the problem persists because trucks dump their cargo in places not designated for them instead of recycling them inside the factory.

3.3. Awareness of Kuwait's Industry stakeholders regarding circular construction

CE is a stepping stone to a more effective CDW management strategy because the loop process ensures that materials remain within a circular loop, reducing the use of raw materials and negative environmental impact while retaining their original quality (Smol et al., 2015). However, according to (Zhang et al., 2022), the waste hierarchy is closely linked to the R-based principles of the CE. Both the waste hierarchy and the CE account for a product's comprehensive life cycle, including the pre-use, use, and post-use phases. The waste hierarchy and the CE have evolved to stress a product's design and use before it becomes waste. The CE and waste hierarchy have a common concept, i.e., trying to manage waste via rethinking, redesigning, and repurposing to improve a product's resource efficacy and reduce waste generation and negative impact. The only distinction is that the waste hierarchy allows disposal, whereas the CE framework does not. On a global scale, CE entails transitioning from a linear "take-make-use-dispose" economy to one that is more circular. CE is economically feasible, which means it is a system that integrates sustainability with profit (Nylén and Salminen, 2019). Circularity implementation will increase the profitability of organizations by reducing resource shortages and price fluctuations, resulting in innovative business opportunities and more effective methods of material production and consumption (Kirchherr et al., 2017; Witjes and Lozano, 2016). The awareness of the CE among engineers in the construction industry is critical, owing to its role in preserving raw virgin materials from depletion and maintaining the health of the environment and society. Furthermore, the extended life of construction materials and increased competition between stakeholders will result in decreased costs and an improved global economy.

The survey (see Fig. 5a) asked whether the participants were aware of the CE concept: i.e., *Do you know what "closed loop construction," often known as "circular economy," means in the construction industry? ("Closing the loop on a product's lifecycle through reuse, repair, or recovery and recycling in order to keep the raw material and product's value")*, with 67% answering "Yes" and 33% answering "No." These results indicate that the CE should be promoted more widely in the construction industry since it is one of the most effective options for promoting sustainability. Raising awareness is critical and can be accomplished by incorporating all stakeholders and emphasizing local, national, regional, and international collaboration in building a global partnership. Kuwait's government projects aim to realize BREEAM or LEED, the credit-based

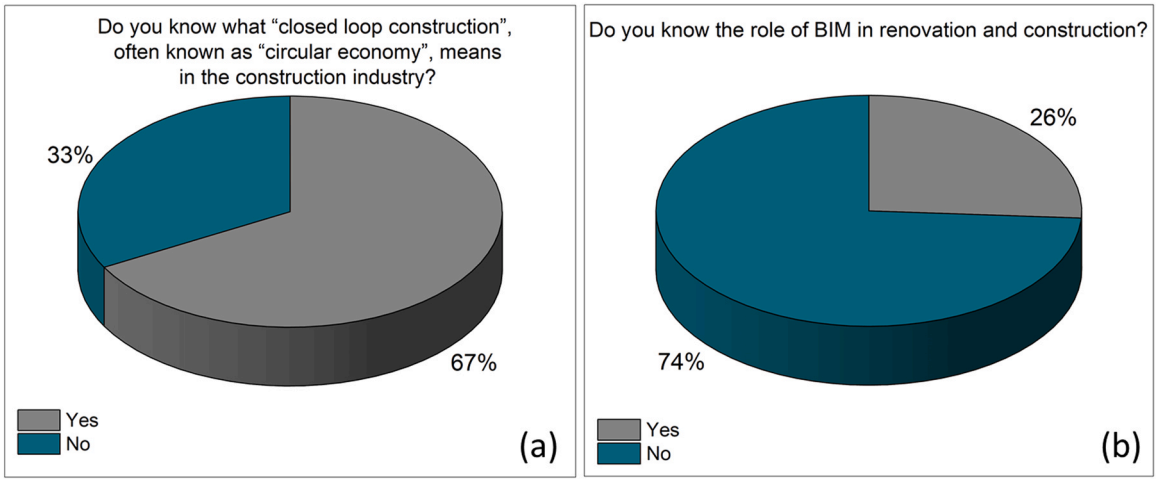

Fig. 5. The awareness about: (a) the CE concept and (b) BIM.

score system tools to verify their practices as environmentally friendly. This is used in the building of the new airport, Jaber Al Ahmad hospital, and many projects of the KISR.

Moreover, these buildings are designed for adaptability and flexibility, prioritizing more appropriate solutions for the end-of-life plans of buildings, using sustainably produced materials (Jurgilevich et al., 2016). In the interview with the EPA stakeholders, we asked about the policies and procedures for adoption that would ensure permanent control of all activities related to waste management. The answers indicated that the stakeholders involved in circular construction are aware of the environmental impact, and the following quote from an interviewee provided evidence of this: "*The Environmental Monitoring Information System (eMISK) was established by the Environment Public Authority to create the world's largest environmental database originating in Kuwait. The system uses geographic information systems (GIS and GPS technology) and remote sensing to support sound environmental decision-making. The system seeks to improve the authority's capacity to monitor environmental sites and activities and aid in the selection process to resolve current environmental issues using the most up-to-date systems available worldwide. In addition, environmental monitoring and measurement and continuous environmental quality monitoring will be performed*".

3.3.1. Awareness of Information technology tools such as BIM in CDW management

BIM is a relatively new technology that has sparked widespread interest and has emerged as a critical component of the CDW management (Li et al., 2017; Liu et al., 2017). BIM is also used to simulate architectural and structural designs and to reduce waste by modifying designs based on simulation results (Abdulfattah et al., 2017). According to the survey (Fig. 5-b), BIM awareness is still limited in Kuwait. Only 26% of respondents were aware of BIM's role in renovation and construction, whereas 74% were unaware of it. This result may be explained by the fact that most participants have worked in the industry for more than ten years, have worked with traditional techniques during that time, and have never needed to learn new methods. This finding stands in contrast to participants' awareness of the CE. Despite BIM's benefits to the construction industry field, Kuwait faces severe implementation hurdles(Abdulfattah et al., 2017). This result correlates with other findings in the literature (Abdulfattah et al., 2017), such as projects that were in keeping with new environmental rules aimed at reducing waste, augmenting efficiency, and increasing production, which faced impediments. The attainment of rapid results is too difficult. However, using novel tools like BIM to implement a collaborative and integrated procurement delivery system could help achieve these objectives. In an interview at the KISR, we asked about innovation programs with eco-innovative solutions employed in circular construction. The following quote is a suggestion from a scientific adviser in the Construction and Materials program at the Energy and Building Research Centre: "*Kuwait's current building standards and guidelines are primarily obsolete and not performance-based. As a result of this situation, numerous civil engineering building structures and road surfaces have deteriorated prematurely, and their operative efficiency and safety have diminished. Recognizing the necessity of regulating construction and building practices, KISR established the Construction and Building Materials program to investigate ways to maintain and improve Kuwait's infrastructure and the performance, durability, and sustainability of buildings. To address concerns about safe and sustainable construction practices, the program has spearheaded efforts to update Kuwait's material and building standards and encourage local industry*".

4. Discussions and conclusions

This study used interviews and questionnaires to comprehensively evaluate the barriers to implementing more efficient methods of dealing with CDW in Kuwait and examined the degree of awareness of circular construction in Kuwait's construction industry. Five individuals with decision-making power and managerial grade with the Kuwait government were also interviewed to highlight the most significant benefits of appropriate CDW management to obtain circular construction. Despite a lack of public awareness, Kuwaiti government initiatives are moving towards becoming environmentally friendly. The government should impose rules and regulations on contractors, requiring them to adopt circular practices and efficient waste management following the 4 R framework in their projects. This should be followed by providing incentives and certificates to contractors to encourage them to be more circular in their approaches. They can achieve higher government ratings, increasing their profile and allowing them to be considered for future projects. Some companies refuse to employ recycled materials because they are more expensive than primary raw materials, and their clients prefer virgin resources. As a result, certifications confirming the benefits of using recycled materials should be provided to reassure clients. There are specific impediments that need to be addressed. From another angle, the costs of the network system for transporting construction waste and raw materials must be reduced. Table 5 summarises the challenges with CDW management in Kuwait with potential strategies to overcome them.

In conclusion, the following future directions are proposed as a way to achieve circularity within the built environment:

- Efforts should be made to increase engineers' awareness of innovative technology, such as BIM, and to improve BIM implementation by preparing construction companies to employ it.
- Increased participation in research and development related to the circular economy and recovery of secondary raw materials is needed to improve their technical specifications and quality. This could generate more income for stakeholders and attract stakeholders who will invest in research to sell materials to developers, resulting in economic and environmental benefits.
- To reduce landfill loads, expenses, and maintenance, there must be an emphasis on CDW segregation on site. Consequently, the cost of

Table 5
Proposed solutions for barriers to implementing circular CDW management practices in Kuwait.

Challenges	Strategies for overcoming them
Recycled materials have high cost and low quality	Research and development to engineer materials with higher performance using smart materials pre-treatments and additives.
Lack of awareness	Encouraging and improving knowledge of sustainable construction and circular construction among different stakeholders in the sector starting from higher educations.
Lack of regulatory control	Stakeholders should collaborate to study and assess current laws and propose revisions or begin new rules and standards pertaining to sustainable/circular construction methods.
Issues with supply chain management	Determining the most efficient waste transportation routes and recycling techniques to save money and the environment by consuming less fuel. Developing more recycling plants with appropriate categorising equipment for secondary raw materil recovery.
Immature market and component	The government should have a suitable framework to encourage and control economic activities. Construction firms and their projects should realise the potential significance of utilising recycled materials in construction projects.

its treatment will be lower, and the revenue generated by selling the superior scrap value. For example, coarse aggregates and recycled steel will be higher. Future research should focus on demand and supply chain issues for recycled CDW material to implement a viable market system and business case.

Data Availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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