CIRCULAR ECONOMY IN CONSTRUCTION - A STAKEHOLDER PERSPECTIVE

DOI: 10.26341/issn.2241-4002-2024-1a-2-T02055

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Abstract
Natural resources are finite, therefore, their efficient use is necessary for a sustainable future in the construction industry. Making better use of the materials at our disposal is paramount for resource efficiency and environmental impact reduction. Additionally, global energy-related carbon emissions from buildings equates to 39%, with 11% of this accounting for materials and construction of buildings. There is an immediate need to decarbonise the construction sector, and the implementation of circular economy can help to that. But the application is currently in its infancy. Successful adoption and implementation, therefore, remains an enormous global challenge. There is a need for businesses to develop effective strategies to overcome the significant barriers to ensure the circularity of materials.

This paper aims to advance understanding of the needs and barriers associated with the implementation of a circular economy to aid in the decarbonisation of the construction industry. A semi structured interview process was used to identify barriers and needs within the construction industry, with participants from different companies providing insights from their roles within construction and material use. The results of this study provide barriers to circular economy in construction and strategies required to overcome these barriers.

Keywords: *Circular Economy, Reuse, Recycle, Disassembly, Deconstruction, Construction, Waste.*

1. Introduction

The world economic forum (WEF) identified that the construction industry annually consumes more than 3 billion tonnes of raw materials (WEF, 2016). This sector demand is largely based on a linear system, causing a high consumption of natural resources and construction and demolition waste generation, Recent studies suggest that current construction and demolition (C&D) waste has reached approximately 40% of total solid waste globally (Islam et al., 2019). A solution for this is the implantation of circular economy which focuses on resource recovery.

Conflicting to the linear model, circular economy aims to optimise resource use and value, avoiding material discarding and tending towards net zero waste (Guerra & Leite, 2021; Gupta et al., 2019; Stumpf et al., 2021). The foundations of circular economy in construction are based on reducing consumption of virgin materials, and replacing the 'cradle to grave' concept with a 'cradle-to-cradle' vision by waste minimisation, recovery of materials and facilitating waste valorisation and waste upcycling to increase the final product value (Lahane et al., 2023). Furthermore, circular economy also includes the reduction of unnecessary

consumption and increasing manufacturing efficiency. A materials economic value can be utilised in the long-term using a circular model. However, despite its potential, barriers remain in the recovery of materials and in the extraction of value form secondary materials (Islam et al., 2019). Barriers identified in current literature include, among others, lack of recovery methods and low value of materials at end of life, as well as issues with warranty and insurance (Guerra & Leite, 2021; Kirchherr et al., 2018).

The purpose of this study is to: (1) Assess stakeholders' awareness of circular economy practices in construction; (2) Assess current circular economy considerations within their organisations; (3) Understand barriers to circular economy within the construction industry; and (4) Understand what stakeholders need to increase the implementation of circular economy within the construction industry to enable a transition from linear economy. Semi-structured interviews were conducted with 5 different stakeholders within the construction industry (Creswell & Poth, 2016), to analyse their perceptions and give a qualitative output to identify knowledge gaps and provide strategies to increase the implementation of circular economy practices (Guerra & Leite, 2021).

2. Circular Economy Strategies and Implementation

The current building stock was designed within a linear economy. Solutions for resource recovery are not present in existing buildings and they are particularly challenging to be introduced. Therefore, a large proportion of construction materials end up as waste during demolition once a building end-of-life is reached. In the UK, waste from construction was estimated to be around 100 million tonnes (Mt): 41.6% excavation waste (soils), 14.7% dredging soils, and 43.7% from C&D activities (Adams & Hobbs, 2017).

The application of circular strategies is dependent on several factors, from design to the end of life of a building, including collaboration between stakeholders. It is agreed within literature that reducing waste generation, extending the life of a building, and facilitating the recovery of resources are paramount in transitioning to a circular economy (Guerra & Leite, 2021). Current literature also shows implementation of circular economy has potential for carbon savings with the reduction of embodied carbon (Bayram & Greiff, 2023; Densley Tingley et al., 2017; Temizel-Sekeryan et al., 2023). Businesses must therefore make adjustments in the way they operate. Instead of looking at resources as if they are non-finite, a closed loop perspective must be applied (Gupta et al., 2019).

Guerra et al. analysed the challenges and barriers to circular economy in the Unites States through questionnaires and interviews (Gupta et al., 2019). When questioned about current construction practices the interviewees suggested that construction and demolition waste generation is highly dependent on the design of a project. It was also identified that current barriers to circular economy include budget, project timelines, awareness, current construction models and lack of regulations. Kanters et al. also identified barriers to circular economy through the interview process (Kanters, 2020). These barriers included a higher financial risk, lack of flexibility in building regulations, supply and demand not aligned, and lack of knowledge about material reuse. It was also commented in this study that a transition to a circular economy is an unavoidable slow process.

3. Methodology

A qualitative semi-structured interview technique was adopted for this research, followed by a thematic analysis of the responses to find insights and consistent themes. Recurring themes were identified within the data and was coded for all participants. Key categories were identified for further discussion.

Interviews were conducted with 5 different participants from the construction industry, with business ranging from small to large enterprise. This is an adequate sample size considered for this study (Creswell & Poth, 2016; Guest et al., 2013; Kuzel, 1992). Participants were selected based on their role within the construction industry from companies working in the UK market. Relevant roles were chosen with the capacity to take decisions on sustainability policies in the company. The parameters considered for the selection of the interviewees were based on the company size (large, medium, small o micro) and type of stakeholder: (designers, contractors and manufacturers).

Table 1 - Semi-structured question framework:

Part A. Background information about the company and participant.
• Company name • Type of company • Role at company
Part B. Implementation of circular economy solutions in the company activity.
• Implementation in design - i.e. waste minimisation, adaptable design, energy efficiency etc. • Implementation in construction - i.e. Reuse waste materials, use of non-hazardous/non-pollutant materials, Up-cycling, On-site waste management plans etc. • Implementation in decommissioning – i.e. Selective decommissioning/deconstruction, On-site waste management plans etc. • End of life/new life products - i.e. Reused and recycled products, new markets, etc.
Part C. Needs, barriers and drivers
• Regulations • Certifications • Skills and Training • Stakeholder collaboration • Supply chain / procurement • Investment and Profit
Part D. Further improvements to achieve net zero energy and waste targets

Semi-structured interviews give the possibility to identify and discuss any other factors the interviewee considers as relevant regarding each of the topics, which would be able to add to the analysis of this research.

Details of participants can be found in table 2, with a participant code assigned to each interviewee. To preserve the anonymity of the interview participants, the initial for interviewee (I) was given followed by a number from 1 – 5.

For this research, NVIVO – Produced by QSR international was specifically used for the analysis of unstructured text from interviews. Transcripts from interviews were uploaded into the software and analysed. Five main theme codes were created to organise the information. (1) Circular economy considerations, (2) Circular economy advantages, (3) Current non-circular economy practices, (4) Barriers to circular economy, and (5) Development of circular

economy. The unstructured text from the interviews was organised and coded to provide emergent themes from the data.

4. Results

Table 2 - Details of participants. The identities of the interviewees have been masked to preserve anonymity and are referred to as I-1 through I-5.

Participant Code	Role in company	Industry stakeholder	No of Employees in company	Annual Turnover
I-1	Supply chain sustainability manager (UK)	Contractor	7000	£3300 000 000
I-2	Commercial Manager	Manufacturer	80	£25 000 000
I-3	Owner	Manufacturer	1	-
I-4	Design Director	Consultancy (designer)	5	£70 000
I-5	Project Director	Consultancy (designer)	57	-

4.1 Circular economy considerations

Circular economy is a more sustainable alternative to a linear economy. However, there is a transition process that the construction industry needs to go through as a whole. The participants in this research were aware of circular economy and the need to transition from a linear economy. This, however, is dependent on a collaborative approach as one interviewee I-5 noted, *'It's a slow burner because we don't buy directly a lot of the materials.. We buy via our supply chain and our subcontractors. So, we do have evidence of circular economy ... but only for construction waste, not demolition waste.'*

Participants also suggested that this is the beginning of the transition and significant learning and education is required for the transition from a linear to a circular economy, as I-5 noted, *'I'm just learning, going through that process at the moment. But there is some SCI* (steel construction institute) *guide and some various other design guides that go through that process'. 'It's a bit of an education for the contractor and the steelwork fabricators to help them through that journey because they are very used to working with new steel and to the very straightforward process' but it is difficult to change that inertia with innovative solutions, in this case, for example, with reuse of steel because ' we don't know how that behaves and we don't know if that will last.'*

It is clear that participants were starting to pay attention to circular economy within their roles as I-4 and I-5 noted, *'When a project comes along where we can show how to do things better and we can practice ways of doing things, then we do them'. 'We're certainly seeing it on the embodied carbon aspirations. They are certainly becoming more and more common across all schemes, and it's certainly something that we pay attention to.'*

The participants made it clear that some circular economy considerations were in place, however further education and a change of mindset is required for the transition. An operational shift is required for all stakeholders within the construction industry.

4.2 Circular economy advantages

There are advantages of implementing circular economy practices, and stakeholders within the construction industry are conscious of these with I-2 giving a manufacturing company perspective on what the advantages of sending waste material back to the manufacturer:

'For us, to collect back the material will reduce the number of skips on site … There's no financial burden to them (the contractor), for the actual practicalities and the costings of doing it works, so it's not costing them anymore. It's saving the main contractor's money. There's a commercial advantage as well as the sustainability message in respect of our investment. … We will see a return on investment because we are then potentially creating feedstock from recycled material and less reliant on oil and the cracking process of producing polypropylene as a by-product of oil, so we will be in control of our own destiny… We can be in control of our own feedstock.'

I-5 also noted that potential high value secondary materials could in future be seen as commodities rather than waste *'Steel within buildings could be seen as a commodity that is likely to be almost tradable.'*

4.3 Current non-circular practices

Participants were asked about the non-circular practices within the construction industry, I-4 noted *'One example is glass, so when we're taking old windows out of a house, we don't appear able to recycle that glass. You can recycle bottles, but construction glass would appear to be unwanted, so it goes in general to landfill. This is a ridiculous idea because it's usually better-quality glass than bottle glass. But we can't recycle it', Regarding gypsum, 'we are required to recycle it, but you try to find a recycling point to actually dispose of it. So currently we piggyback on a specialist plastering company that we use and put our plaster in their skip, but even then, not absolutely sure what's happening to that skip.'*

I-2 reasoned why the product they manufacture cannot be reused, *'it's protecting the floors, whilst it's in a construction site. It's getting covered in muck, dust, plaster, paint and other contaminants and screws embedded in it. (The contractor) don't want to transfer that dirty use protection to the next project because they are just taking that contamination with them.'* This product maintains circularity by being recycled. It was noted that other manufacturers do not have recycling technology therefore, *'after its use would be to go through the mix where streams and then to landfill or waste to energy.'*

I-1 stated in relation to the reuse of timber, *'A lot of timber pallets end up in skips and they won't get recycled or get recycled into animal bedding if they're clean. If they're not clean material, they probably get made into particle board or sent to incineration for bioenergy.'* And *'A lot of timber hording is unusable after two years and, because it's painted, it's classed as B or C categories on waste'.* If it is classified as B and relatively clean material, it can be chipped and transformed into particle boards, but mixed with 20% clean material. On the other hand, if it is classified as C, the material is incinerated and not reused. It was suggested that metal or plastic hording can be reused. I-1 also suggested the reuse of glulam beams rather than recycle as, currently, *'timbers contain glues, and they will more than likely get incinerated.'*

I-4 stated that one of the biggest issues that needs addressing is *'there is less waste segregation in construction waste than there is in domestic waste.'* This would be a simple solution to implement in circular economy practices on site.

4.4 Barriers to circular economy

Participants were asked about what current barriers to circular economy they have identified in their own experiences, I-4 stated that the current VAT environment is impacting retaining current buildings. They stated: *'probably the greatest circularity in our work is making sure that we demonstrate the viability of retained buildings rather than demolishing, which is not easy given the VAT environment. A new build house is 0 VAT registered, whereas if you buy an old house and do it up, you're paying 20% VAT on anything other than the thermal improvement work.'*

I-4 also stated that we do not know what the best practices are for circular economy and further research must be done, they said: *'I don't know whether it's actually better to use mechanical fixings that you can dismantle later or grind them out when you pump up the board, or whether to use a glue where you then don't have those metals to be reclaimed in it at all.'* I-1 also commented on the lack of understanding stating *'the other thing as well is an understanding of what products we can reuse inside that building',* Whilst I-1 and I-4 stated the need for further research, I-3 (micro-company) commented that one of the biggest barriers they had faced was the lack of funding to undertake such research, *'There was no funding available to continue the research that I was doing.'*

I-2 stated that one of the biggest barriers was breaking habits that workers have built throughout their careers. They stated, *'We're trying to break the habits of the lifetime in the UK construction industry. We always disposed of it and send it through the mix waste streams. The difficulty we face is having the site teams being practical setting it aside, segregating it and then calling us. It's a quite a simplistic method: your labourers on site are stripping it out, so don't put it in that skip; put it to one side, then we'll come and collect it within 48 hours'*. I-5 made a similar comment, *'I think we're very stuck in our ways. ... I think it's the same with any part of society. We don't like change as a cultural thing… It scares us a little bit. What's the insurance going to do? What are the warranties on this? How do we deal with this?'*

I-2 (manufacturer) also mentioned issues getting material back from construction sites, *'So we try and make it as easy as possible for sites, but we can't enforce it because, at the end of the day, the project management or the team on site don't work for us. They work for the main contractor and we are a supplier to them. We can suggest it, we can give them the benefits of what they'll achieve by doing so, but it does boil down to the individuals on site to make that decision. ... currently we're not getting enough recycled material back and, to produce 100% of our output, we're only collecting back around 15% of our output.'*

I-2 specified that stakeholders need to make investments in personnel to help move towards a circular economy, *'there are companies that have one sustainability manager, and that person is just up against it.'* They also stated that it becomes an issue because *'it's not legislated'*. Another barrier I-2 faced was sustainability not being a priority for some individuals, *'Sustainability slips down the pecking order of priority, and that's proved difficult. So, the barriers we see are dealing with the individuals who don't prioritise.'*

A further barrier that was mentioned by I-1 was cost and time during demolition*, 'When we're discussing demolition projects with the next set of demolition subcontractors, what they should be doing to help promote circular economy is cost. There is no cost in construction. A lot of the take back schemes are free from the manufacturers. But (the problem is) when it comes to a demolition project…If (the demolition company) contaminates those products when taking them out, then there's a good chance that those products can't be recycled and that's why the problem will be an increasing cost for demolition projects, because they'll have to remove them in a more careful manner than they have done in the past, which will probably take them longer. ...It's going to take more time. That's more cost.'* This barrier about the increase in cost of demolition was also mentioned by I-5, stating that it would

become more expensive and time consuming when *'looking at an existing building that was built X amount of years ago, and you have to prove that it's ok to take and carefully catalogue these different bits. So, there's probably a little bit of extra time involved and therefore a little bit of fee associated with that design fee.'* The increased in cost of demolition was also mentioned by I-3: *'the responsibilities just passed on, and then, who is taking the bill for the extra work? or the extra activities being forced upon the demolition company who have to change the procedures? Who's taking the extra added cost that happens there?'* I-4 also stated that costs can be increased by implementing circular economy, *'I can see a model where either you have somebody who redesigns the skips, or you have a version where mini skips are viable because, actually, at the moment mini skips are not cost wise. You buy an 8 yard if you're going to do it, you don't buy a collection of little two yarders even though actually from a waste recycling perspective that might be a better idea, but that is going to cost 3 or £400 more per round, if not more. ... So we can't afford to do that.'* I-4 also noted *'there's very little incentive to do it realistically.'*

I-1 mentioned that the availability of materials is currently an issue *'subject to availability as well as the section sizes and the grade of steel that you need is available in the market to build that building',* although this problem can be addressed as long as more companies implement circular economy and more material is readily available for reuse.

I-1 alluded to the lack of communication between different stakeholders: *'everyone gives waste to the recycling company, but nobody is speaking to the manufacturer apart from us. So, you can see that when the clients got the building, they're probably unaware of the circular initiatives that manufacturers offer. ...demolition contractors and manufacturers are not talking to each other. Not many people are aware of the options that are available within the United Kingdom with the manufacturers ... But certainly, it has to be pushed by the contractors and it has to be pushed to the demolition contractors and also the clients need to be aware. So, it's more awareness of what's available'.*

I-1 also mentioned insurance as a barrier for the reuse of materials: *'even though you might have a perfectly reusable frame to begin with for that building, the insurance companies are unwilling to insure that building because it's an old building and they're not going to warrant that frame. So, the insurance industry needs to change their perspective on where the risk lies in terms of insuring the steel frame or an existing concrete frame.'*

A barrier that SME face is lack of training, as I-3 stated, *'I still don't have enough knowledge to be able to understand and calculate the carbon output of my own actions.'*

4.5 Development of circular economy

One of the biggest practices that needs to be improved for circular economy is communication and collaboration, I-1 mentioned *'it will be important if we (main contractor) appoint the demolition contractor, to make them fully aware of these schemes. And the other one is the waste recycling company, the waste recycling company will have their own supply chain, but they again need to be made aware that manufacturers offer these take back schemes.'*, Whilst I-3 commented, *'I really believe that if you're going to make something sustainable and long term and circular, we have to involve everyone and we have to collaborate.'*

An education on circular economy is also needed to increase implementation, I-5 stated *'There's definitely an education piece there for the whole industry and for contractors in particular', 'I think there's an education there and it's making these things become more normal.',* I-1 also mentioned that *'a road map and better understanding'* is required *'so everyone's aware of who to contact. basically, you're creating an industry that is fully aware of what options they have. At the moment, a lot of contractors don't realise a lot of these take-back schemes exist from the manufacturers. The demolition guys definitely don't know that*

they exist and, when the demolition guy comes to strip out that building, (they don't know) what options they do have other than sending everything to the waste recycling centre,'

Participants also noted that there needs to be developments in waste segregation, I-4 commented *'I can see a model where either you have somebody who redesigns the skips or you have a version where mini skips are viable ...let's have some proper thinking around waste segregation.',* whilst I-1 also stressed the importance of keeping waste material clean involving actions from the different actors in the refurbishment or demolition process, mainly the client, the contractor or the demolition company *'rather than throwing all into the skip with everything else… and getting them covered in dust, debris, rubble and so on.'*

There is also a need for new buildings to be designed for reuse so circular economy can be more easily implemented in the future. I-5 stated, *'there are two issues… there's reuse of existing buildings and then designing your buildings to be reused in the future. ...Maybe changing the way we detail things to make them more demountable.'*

The need for legislation was also mentioned by participant I-5 who commented the need of *'a planning requirement or a local legislation requirement*'. I-2 also mentioned the need for legislation to increase the implementation of circular economy, *'We're ready for it now, we'll take material back from site now, but I don't think the industry's quite ready, so until legislation or financial penalties come in and force it somewhat, it still remains a choice of the individual project manager what to do with it. And until they don't have that choice, we'll still lose protection on site and it'll end up in mixed waste streams.'*

Participants also stated the need for incentives, I-3 commented, *'I think that the if there were some incentives in terms of showcasing the sustainability aspect and benefits that companies can see,'* whilst I-1 stated the possibility of penalties in addition to incentives: *'The construction industry is definitely a cost led industry and especially the private sector. So, the more cost effective they can make these products, the more likely they get used, and then it's about education. What you could have then is some kind of incentive to make sure that these products get back to the manufacturers. It could be a cost incentive, or it could be some kind of penalty with the manufacturer to get them to push it harder.'*

5. Summary

A linear economic model is unsustainable. It is susceptible to disruptions in supply and fluctuations in price. It therefore poses risks to business and clients. A circular economic model would ensure a consistent supply of materials and reduce dependency on the production and supply of raw materials. The table below outlines some of the strategies that can help overcome the current barriers in the construction industry.

The participants in this research accepted that there is a need for circular economy practices in the construction industry, but further action is required from all stakeholders. Despite this, there are challenges with stakeholder engagement and difficulties in construction operations for circular economy practices to be implemented now. However, it is widely accepted that it is beneficial to shift from a linear economy model to a circular economy model.

For the implementation of circular economy practices there needs to be shift in the mindset of all within the industry as a system change is required. It was also noted that information and training is not readily available. The results of this study align with the studies of Guerra et al. in the United States (Guerra & Leite, 2021) and Knaters et al. in Sweden (Kanters, 2020), as presented in section 2 of this study.

This research is exploratory in nature and limited in terms of the number of participants in the interviews. Additional interviews are required for further work.

Table 3 - Summary of suggested strategies to overcome barriers in circular economy.

Barrier	**Strategy Suggested**
Lack of Understanding	Research Education Training
Habits / Unwilling to change	Education
End of life not considered in design	Design for deconstruction Design for reuse Design out waste
Supply chain focused on linear system	Improve circular procurement approaches Innovation. Waste as new materials New markets for reuse and recycling
Return of materials to manufacturers from construction sites	Improve waste segregation Take-back schemes Stakeholder collaboration Incentives and penalties
Lack of personnel with knowledge	Investment in personnel training
Lack of legislation	Development of government policies, standards and regulations
Demolition cost increase	Design out waste Better planification Improve waste segregation Stakeholder collaboration Take-back schemes Higher quality and higher value uses for waste
Lack of communication	Knowledge sharing Stakeholder collaboration
Insurance of reused/recycled products	Quality assurance procedures

Acknowledgements

The authors would like to thank all the stakeholders who took part in the interviews and The University of Salford Innovation Strategy Fund for funding the project: Creation of Hub for Circular Economy in construction.

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