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Innovative environmentally sustainable concrete: Explaining the low uptake in UK construction Activities

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ABSTRACT AND KEYWORDS

Purpose of this paper

This study explores the reasons for the low uptake of innovated environmentally sustainable concrete by the UK construction industry. Despite the significant impact the manufacturing and use of concrete has on the natural environment on the one hand, and on the other, the commitment of the UK construction industry to the UK Government's carbon emissions target, it is of great concerns that innovated environmentally concrete is disregarded by the industry. Concrete is the second most used building material in the world; it is comprised of cement, sand, aggregates and water; all of which are critical to the ecosystem and the environmental media. The cement within concrete accounts for 8% of total global CO2 emissions whose atmospheric concentration induces unpredictable changes in global weather patterns euphemistically referred to as climate change, and with devastating consequences. Against this background, governments around the world have voluntarily established carbon reduction targets, and in the case of the United Kingdom, this target has been set at 80% to be achieved by 2050. To this end, various policy instruments have been introduced by the UK government to encourage households and businesses, which are deemed as critical partners in the delivery of set reduction target. This is why it is important to ascertain why innovated sustainable concrete is not widely used in UK construction despites the efforts of the government and the commitment of the construction industry to sustainable operations.

Design/methodology/approach
Apart from the critical literature review undertaken to appreciate and understand previous research efforts relating to product innovation generally, and in particular, innovation within the construction industry, a qualitative research methodology was adopted, given the desire for greater understanding of product innovation trends and challenges in the construction sector, albeit with particular focus on the low uptake of sustainable concrete. A semi-structured interview was conducted on construction professionals who have particular interests and expertise working in the UK concrete industry supply chain. The results were thematically coded using open-coding and analysed into factors that influence the uptake of new sustainable concrete.

Findings
The main factors established that explain the low uptake of innovated environmentally sustainable concrete in the UK construction industry include; cost, quality, practicality, testing and durability issues, risk avoidance, poor marketing and promotion, government policy, construction culture as well as lack of cohesion and collaboration in the concrete supply chain. Conclusions and recommendations were established based on these findings to encourage the uptake of innovated sustainable concrete in UK construction activities, and enable the UK government fulfill its reduction target for carbon emissions.

Research limitations/implications (if applicable)
The study is limited to concrete and the United Kingdom. The implication being other innovative environmentally sustainable building materials may also be encountering similar market penetration challenges as sustainable concretes. Similarly, this situation may not be unique to the United Kingdom in which case, meeting carbon emissions reduction targets set by many countries may prove more

difficult than would have been previously envisaged without critical attention being paid to the sustainability attributes to construction input supply chains.

Practical implications
This study provides insights to acute challenges facing environmentally sustainable construction materials in the market place and allows targeted interventions that will ensure innovations in construction materials are not stifled in the UK.

What is original/value of paper.
Findings and conclusions drawn from this study will not concentrate minds on how to better support construction product innovations, a necessary move that will assist global efforts in meeting carbon emissions targets.

Keywords: Concrete, Cement, Environment, Sustainability, Innovation,
Supply-Chain

1. Introduction

Construction is an industry that has an enormous impact on the environment, given the huge consumption of raw materials and generation of wastes (Holton et al., 2008). The extraction and transportation of these raw materials invites significant alterations to the eco-system, as well as significant emissions of green-house gases into the environmental media (Khatib, 2016). Currently, the world is consuming these raw materials in a highly unsustainable manner. In the UK for example, 420 million tonnes of raw materials are consumed annually by the construction industry (Khatib, 2016).

Concrete, which is a mixture of cement, sand and water, is a versatile building material, and one of such materials whose production and consumption invite significant alterations to the natural environment (Watts, 2019), and the unsustainable methods of extraction employed often undermine the regenerative capacity of the natural environment. Cement is a critical material in the manufacture of concrete, this explains the interchangeable use of concrete and cement in the building material literature. Concrete features prominently in almost every form of construction, including buildings, roads, bridges, and other critical infrastructure and services, and annually, over 10 billion tons of concretes are manufactured globally (Meyer, 2009). In the process of concrete production, significant amounts of green-houses gases are released in addition to the environmental impact of other key material inputs – water and sands. Globally, cement production has increased 4-fold over 30 years, from 1 billion tonnes to over 4 billion tonnes, this is expected to increase annually by 500 million tonnes (Vidal, 2019), and already, cement accounts for 8% of the world's carbon dioxide emissions (Rodgers, 2019).

Generally, cement production ranks third behind transport and the energy sectors that contributes man-made or anthropogenic CO2 emissions to the environmental media (Andrew, 2018). There are two crucial stages of cement production from where the bulk of CO2 emissions derive: the first being at the stage where by-products of fossil fuels, mainly coal, are burnt to generate heat for driving the cement-making process; this is followed by the critical second stage where the thermal putrefaction of calcium carbonate takes place, leading to the production of cement 'clinker' (Watts, 2019). It is at this second stage that more than 50% of carbon emissions associated with cement production is released (Watts, 2019). According to Vidal (2019), every 1000kg of cement produced involves the release of 1000kg of CO2 into the environmental media.

The continuing use of concrete is on the rise, this owes to its key attributes that start cost-effectiveness, fire resistance, and mechanical and high durability (Meyer, 2009). The implication of such rising demand for concrete is the associated carbon emissions, and unless effective measures are taken to decarbonise concrete production, global carbon emissions target will be difficult to achieve. It is on this stark reality that persuaded the UK concrete industry, which include concrete manufacturers, the aggregate industry, the ready-mixed industry, and the precast sectors together with other interrelated sectors to agree and commit to the Concrete Industry Sustainable Strategy (CISS) in

2008. This strategy was revised in 2012 with various sustainable commitments to be achieved by 2020.[1] In particular, it was expected that by 2020, the concrete industry would have achieved:

- 90% decrease in wastes destined for landfill by 2020, taking 2008 as a baseline.
- 30% reduction in CO2 emissions from concrete production by 2020, taking 1990, as a baseline.[2]
- Achieve 95% BES 6001 responsible sourcing certification standard by 2020
- 100% of relevant production sites with action plans for site stewardship and biodiversity

These developments followed from the UK Government's commitment to a general target of 80% reduction in CO2 emissions (Zhao and Pan, 2015). Indeed, concrete manufacturers and allied sectors have adopted series of measures aimed at minimising emissions of greenhouse gases from their production and distribution activities.

2. Innovated Environmentally Sustainable Concrete

Huge efforts have gone into decarbonising concrete production (Holton, et al. 2008), this is reflected in Figure 1 which shows the amount of patents filed by the cement and concrete industry continues to outgrow other energy and natural resource intensive industries. The particular area of focus is in finding alternatives to 'Clinker', a by-product whose procession generates more than 50% of carbon emissions associated with cement and concrete production.

Figure 1 Innovation in Low-Carbon Cement and Concrete

Source: https://reader.chathamhouse.org/making-concrete-change-innovation-low-carbon-cement-and-concrete#

The manifestations of these innovations can be found in the increasing decarbonisation of cement production round the world. As Figure 2 indicates, the cement industry has witnessed the increased use of alternatives to clinker, including limestone calcined clay cement, or 'LC3', which are found to reduce CO2 emissions associated with cement production by as much as 20% to 30%. In India, this method of cement production is being tested on a large scale, as the country sees it as a necessary

[1] Construction 2025: industrial strategy for construction – government and industry in partnership. https://www.gov.uk/government/publications/construction-2025-strategy.
[2] Cement Industry Carbon 2050 Strategy (Mineral Products Association) http://cement.mineralproducts.org/current_issues/climate_change/carbon_strategy.php

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strategy for achieving its carbon emissions target, and this is particularly given the expected exponential growth in cement consumption owing large scale infrastructure supply. Other materials have been innovated in place of clinker, these include slag and fly ash that has drastically reduced clinker input to cement manufacture by 50%. Overtime, 'Portland Cement' has been partially substituted by other cementitious materials, including ground granulated blast furnace slag (GGBS), and other admixture and additives. These innovations have not only allowed for reductions in carbon emissions, but also, it made it possible for concretes to be produced into different compressive strengths (Kusuma, et. al. 2015). Furthermore, recycled aggregates are also being used in concrete production, further decarbonising concretes production (Meyer, 2009).

In the UK, the use of GGBS in concrete production is growing, and this owed mainly to numerous advantages adduced, including greater durability, increased strength, reduction in heat generation, resistance from sulphate attack, and lower greenhouse gas emissions (Kim et al., 2018). Indeed, it has been found that using GGBS instead of conventional aggregates facilitates annual reductions of 2.5 million tonnes of CO2 emissions (Tait and Cheung, 2016; Meyer, 2009). Furthermore, Hanson, a major UK ready-mix supplier of concrete indicates that it has been able to replace 70% of Portland cement (CEMI) in ready-mix concrete with sustainable alternatives resulting in significant reductions in CO2 emission reductions.[3]

Figure 2 **Innovation in Cement Production**

Source:

Source: https://www.zkg.de/en/artikel/zkg.html

However, the efforts of concretes manufacturers at decarbonising have not been rewarded with increased demand for innovative sustainable concretes, as up-takes of these products have falling drastically below expectations. While various explanations have been abstracted from the challenges facing newly innovated products coming on to the construction markets (Reijonen and Croisel's, 2017; Hardie, 2010; Davis et al, 2016; Vidal, 2019), little study exists on the challenges facing concretes. (Ozorhon and Oral, 2017). Indeed, Vidal (2019) argues that the low-uptake of innovated sustainable concrete in the UK can be explained by looking at the challenges faced by new construction products face entering the market, including industry culture, attitude to risks, and concerns about quality and standards. Evidently, the scarcity of literature on the reasons for low-uptake of innovated sustainable concretes in the UK, despite the proven sustainability attributes, remains the motivation for this study. Understanding the reasons for such low demands for this products is a necessary prerequisite for targeted policies and strategy for decoupling increased production from CO2 emissions.

Several objectives are pursued in this study to enable the realisation of the aim of study. The first objective is to establish the effects of concrete production and use on the environment, and this provide context to the study. Secondly, to understand and analyse the characteristics of innovative sustainable. Thirdly, to establish the reasons for the low-demand for innovated sustainable concretes

[3] https://www.hanson.co.uk/en/ready-mixed-concrete/sustainable-concrete

despite beneficial environmental attributes and particularly in regards to both commitments of the construction industry and the government to decarbonise the industry, and finally, to suggest appropriate policies and measures to accelerate the use of sustainable concrete in UK construction industry activities.

2. Research Methodology and Strategy

The research question that results from reviewing the literature and contextualising of the low-use of innovative and environmentally sustainable concrete in UK construction activities lend itself to the use of qualitative research methodology. This owes to the fact that it is the unique views and opinions of construction industry practitioners, evidenced by their experience and duration in the industry, that is sought to deepen our understandings of the challenges faced by sustainable concretes in the UK construction industry (Ritchie and Lewis, 2003). Thus, the qualitative research methodology is used in this study to enhance our knowledge and deepen the meaning that can be adduced to explain the low-uptake of sustainable concretes in UK construction activities (Ritchie and Lewis, 2003). The underpinning ontological and epistemological positions adopted for this study hinge on knowledge being seen as a social construct in which it is determined by culture, values, and specific conditions the researchers have encountered (Ritchie and Lewis, 2003). As such, the epistemological positioning of the authors is of interpretivism, with the use of a qualitative research methodology to look at the factors that lead to low uptake in the use of new innovative sustainable concrete. According to Wildemuth (2016), knowledge gained from culture and values derive from research investigating ‘why?’ and ‘how?’. The data obtained can be analysed using inductive reasoning to understand specific contexts, which in this case, is the low-uptake of innovative sustainable concrete in UK construction activities (Ritchie and Lewis, 2003).

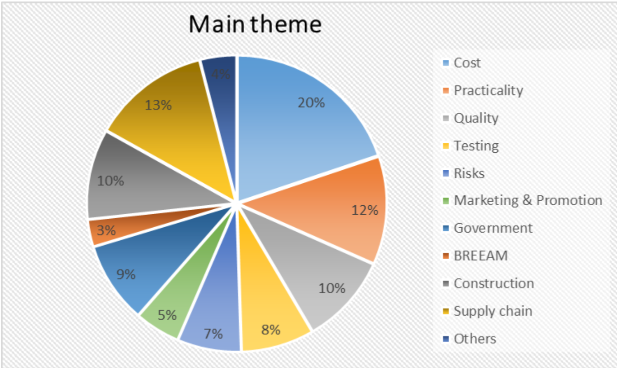
The data were collected using a structured questionnaire in a cross-sectional survey with purposive or non-probability sampling technique. The purposive sampling strategy was chosen for reasons of costs and time constraints. The sample size of participants requires the right balance of numbers to provide depth and breadth to the research (Cleary, Horsfall and Hayter, 2014, Mason 2010). However, Mason (2010) observes also, that too many participants can lead to saturation; more participants do not necessarily result in more valuable information other than repetitive and redundant information (Mason, 2010). Sample sizes averaging between 20 and 30 participants are deemed adequate, and beyond which saturation begins to emerge (Mason, 2010), leading Atran et. al, (2005) to advise on a minimum of 10 interviewees.

The strength of this study, irrespective of the sample size, is the quality of interviewees that comprised an array of professionals within the industry. These include quantity surveyors, directors, engineers, construction manager, health and safety managers, technical and research staff to afford broad perspectives on the research. Furthermore, the construction industry experience of participants ranged from 4 to 45 years, with a collective industrial experience of 379 years, providing a significant wealth of practical knowledge and understanding of the UK concrete industry. This will also enhance validity and reliability of research results (Cleary, et al., 2014). As Table 1 shown in appendix 1 reveals, 21 interviewees with extensive knowledge of the UK construction industry were identified and interviewed. The interview questions are similarly presented in Table 2 in appendix 2.

3. Analysis of Results

Figure 3 is a summary of the interview responses in appendix 3, the responses have been grouped into eleven main themes explaining the low-uptake of innovated environmentally sustainable concretes, and these themes have been further disaggregated into sub-themes.

Figure 3



The dominant reason given for the low up-take of sustainable concrete in the UK construction industry is the costs of the product, which clients are unable to accommodate. A disaggregate analysis of the origin of costs points to that of ‘clinkers’, which is considerably less than those of sustainable alternative inputs to concrete manufacturing, which are then reflected in final concretes prices. This seems to be the overwhelming views of industry practitioners, particularly the quantity surveyors who argued that clients are unfavourably disposed to bearing such costs. This finding coincides with those in the literature that sustainable alternatives to clinkers are relatively more expensive, and shown to the main reason that conventional concretes remain very popular with clients. In other words, sustainable concretes remain relatively uncompetitive in price, hence the difficulty in penetrating the market for concretes. The issue of cost was further probed where the environmental benefits and associated low running costs were pointed out to participants. The responses from respondents were instructive, the overwhelming view indicates that very few property developers take such a long-term view of investments; this they argued to be particularly the case, when such investments are likely to change hands after project completion. Other elements of costs relate to ‘testing and trials’ for durability and structural integrity - processes critical to establishing product quality.

Practical problems associated with production and manufacture was the second major theme raised by respondents. The low cement content or the total substitution of other sustainable alternatives for cement are deemed problematic, particularly the longer time it takes to for the concrete to set, causing delays and distorting completion time resulting in cost-overrun. In particularly, majority of the participants pointed to the practical problems associated with graphene given that, the supporting theoretical formulation often proves difficult to replicate during manufacturing. One of the participants went further to discuss the difficulty of dispersing graphene into concrete on a large scale, as concrete needs 1300L of water for an 8m3 wagon load of concrete. This poses the difficulty of dissolving and dispersing graphene evenly in the batching plant, which is then put into concretes and having to repeat the whole process again within minutes for the next load of required concretes. Participants also indicated the numerous tests associated with the use of new products, trials and mock-ups using new alternative concrete mixes have proved relatively expensive.

Additional costs identified include those associated with the use of innovative concretes, including those relating to high rework costs. One participant in particular, who had to revert to using conventional cement acknowledged the costs associated with using new innovative type of concrete with plastic fibres was enormous owing replacements of blocked pipes that resulted in extensive wastage of building materials.

Concerns about quality of innovated environmentally sustainable concretes was a major reoccurring theme during the interview. In particular, the strength and durability of sustainable concretes were advanced as main concerns. Participants of design and structural engineering background indicated their reluctance to specify newly innovated materials such as sustainable concretes without established evidence of durability over the physical life of the infrastructure concerned. They pointed to the limitations brought about by the fact that their public indemnity insurance does not account for the risk of specifying untried and untested materials. They argued erring against such caution will have adverse effects on business margins.

Another aspect of ‘testing for durability’ raised is absence of standardised testing regulations and procedures, as existing measures have continuously lagged behind the speed and rate of innovation in concrete manufacture, which in turn, heightens the risks associated with their use. One of the participants who is a sub-contractor holds the view that the cost associated with taking risks with newly innovated products is too much for clients to bear. In his opinion, there is need to build in a premium rate, at least, for the first couple of years to cover any such risks, otherwise clients may be unwilling to bear such risks. Shifting attitudes and perceptions to facilitate market penetration invites higher marketing and promotion costs. According to another respondent, lack of market penetration affects volume production without which unit cost remains ‘sticky upwards’, as economies of scale is forfeited, leaving sustainable concretes largely uncompetitive. However, some of the participants hold the view that it is only a matter time for a downward pressure on prices for sustainable concretes, pointing to wider availability of GGBS alternative, which was previously very scarce. This will allow increased production and allowing for relatively competitive price for standard concrete mix. Indeed, one of the participants hold the view that volume production and availability on the market is critical to sustainable concrete becoming widely used in UK construction.

The importance of practical knowledge about the performance and use of sustainable concrete is critical to market penetration, according to all the participants. Personal experience using innovated light weight concretes on site was tendered by some of the participants, the highlight of the discussion is the importance of training operatives such as sub-contractors on how to handle newly innovated concretes. In the particular example offered, trainings on how much water is required to ensure that the exact amount of water required to pump concretes is what is retained. He argued that the low-uptake of innovated building products generally, and sustainable concretes in particular owe to lack of sufficient knowledge about how to use the new products. This is said to be particularly the case with more complex mixes which are susceptible to moisture and other external conditions. According to majority of the participants, this has serious implications for occupational health and safety. The specialist health and safety participant highlighted the importance of having rigorous procedures in place to ensure new materials enhance rather than compromise health and safety on sites. The blockages that often accompany the use of innovated plastic fibre concrete have resulted in more manual handling of pipes to effect repairs.

Other issues considered important by participants relate to the necessary steps to ensure wider-uptake of innovative sustainable concrete, particularly the resistance to change by the construction. The culture of sticking with what you know and becoming risk-averse to modern construction techniques need to change. Examples were tendered where workers continue with conventional solutions to cracks in concretes instead of using the new self-healing concrete. Similarly, participants were unanimous on the role of the government in encouraging up-take of new products that add value to the environment and contributes towards the realisation of their carbon emission target. Also, the roles of professional bodies, construction product manufacturers and others such as BREEAM in disseminating and organising training programmes in support of newly innovated products were also emphasised.

4. Discussion of Findings

This study establishes the potential of reducing the impact of the built environment on the natural environment by focussing on the supply chain of construction materials. The case of concretes shows that substituting innovated environmentally sustainable concretes for conventional concretes can lead to reductions in carbon emissions, and by extension the built environment in general. There is urgency in adopting this strategy for the decarbonisation of the construction industry, and this owes to the versatility of concrete as a building material, the huge amount consumed in the process of maintaining existing infrastructure and services, and replication in areas of disamenities. Despite the environmental benefits, newly innovated construction inputs, such as sustainable concretes face several challenges coming on to the market. These challenges are in the main to do with concerns about quality and durability, and the attendant impacts on costs that construction industry clients are generally unwilling to bear.

Following the findings, it is crucially important to mitigate the risks associated with the use of innovated sustainable concretes, or indeed, other innovative sustainable products, through public indemnity insurance. The reason being that clients' insurance do not cover the risks of using newly innovated concretes that have not been sufficiently tested. Similarly, a standard Care Certification and level of testing is necessary to reassure the industry about quality and standards of newly innovated products coming on to the market. The point raised by one participant is instructive in that there was no BREEAM points allocated to structural frame until recently, which is why there has been no focus on sustainability and use of sustainable materials in designing structural frames. Also, the need for all stakeholders to communicate and work towards a common purpose in order to create the much need awareness about newly innovated products, such as sustainable concretes, is essential.

The role of the government in promoting the use of sustainable construction products is critical if these products are to successfully penetrate the market and compete with conventional construction products. This can be achieved through the use of command and control measures - regulations, statutory instruments, and economic incentives through taxations. Buildings and other infrastructure constructed from sustainable concretes could be exempted from property rates or offered tax rebates to the tune of carbon emissions saved. Alternatively, the unsustainable conventional concrete could be taxed to the tune of CO2 emissions associated with the facility – 'carbon tax'. This will facilitate market penetration and enhance competition in the market for concretes. Above all, the government could insist, as with the Building Information Model (BIM) initiative, that all public buildings and infrastructures should be constructed from sustainable concretes. Such a move will force the wider use of sustainable concretes, leading to increased production and downward pressure on unit price.

5. Conclusion

In conclusion, this study provides useful insights into the challenges facing innovative sustainable concretes in the market place. In particular, the factors responsible for the low demand for innovative and environmentally sustainable concrete in the UK construction industry have been critically analysed and possible solutions and strategy discussed. Furthermore, the study shows the importance of proactively decarbonising the construction industry by focussing on the supply chain of sustainable products; this will allow the nature of the challenges they face penetrating the market to be better understood for a much effective and targeted policies to be applied. Concrete is a vital building material that has witnessed phenomenal growth in demand, as demand for infrastructure and services rise to support increasing urbanisation and growth and development, more concrete will be demanded, which is the reason for seeking a more sustainable manufacturing process.

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Appendix 1

Profile of Interviewees

Participant	Type of company	Job Role	Years of Experience
1	Subcontractor	Engineer	30
2	Subcontractor	Quantity Surveyor	9
3	Main Contractor	Structures Manager	10
4	Subcontractor	Quantity Surveyor	5
5	Subcontractor	Health and Safety Manager	35
6	Subcontractor	Commercial Director	45
7	Subcontractor	Engineer	5
8	Subcontractor	Commercial Manager	13
9	Subcontractor	Construction Director	22
10	Subcontractor	Pre-construction Manager	18
11	Subcontractor	Concrete Technologist and Quality manager	15
12	Engineering Consultancy/ Designers	Director	23
13	Subcontractor	Construction Manager	34
14	Main Contractor	Civil Site Engineer	4
15	Subcontractor	Senior Engineer	11
16	Subcontractor	Commercial Manager	15
17	R & D Sustainable Cement Specialist	Research and Development Director	22
18	Concrete and cement Supplier	National Technical Manager	35
19	Structural engineering/ Architect	Associate Director	11
20	Client/ Property Investor/ Property Developer	Director of development	3
21	Client/ Property Developer	Quantity Surveyor	14

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Appendix 2

Table 1 Interview Questions

Nos. of Interviewees	**Questions**
1	What is your job title?
2	What type of company do you work for?
3	How many years of experience do you have in the industry?
4	Have you used, specified or supplied any innovative environmentally sustainable form of concrete or concrete-mix in the past?
4(a)	If yes to question 4, why did you do so, and what were associated advantages using it?
4(b)	If yes to question 4, what were the advantages associated with their use?
4(c)	If no to question 4, why?
5	What factors do you think about when choosing concrete types?
6	Here is a list of innovative types of concretes that research suggests are more environmentally sustainable than conventional concrete: a. Cement free b. Hempcrete c. Graphene d. Plastic concrete e. Self-healing concrete f. Geopolymer concrete g. Carrot and beetroot concrete
6(a)	Have you used or specified any of the concretes listed in 6 above?
6(b)	If yes to 6(a), why did you specify them and what were the advantages associated with their use?
6(c)	If yes to 6(a), what problems arose, if any?
7	If no to questions 4 and 6, can you explain why you have not considered using innovative environmentally sustainable concrete?
8	There is a low-uptake of innovative environmentally sustainable concrete in the UK construction industry. Why do you think this is the case generally?
9	Who normally makes the decision on the type of concrete to use in your organisation?
10	In your opinion, who is best placed to drive sustainability innovations in the concrete supply chain?
11	Is sustainability a factor you consider critical in the projects you are involved?
12	What do you think will encourage increased use of innovated environmental sustainable concrete in the UK construction industry?
13	Have you noticed any changes over the years with types of concrete used?
14	Do you see a role for the government in encouraging the use of innovated environmental sustainable concrete?
15	Any other points or issues you would like to raise?

Appendix 3 Table 3: Frequency of themes raised by interviewees

Main Themes	Sub-Themes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Sub-Theme Frequency	Main Theme Frequency
		Interviewee Participants																						
Cost	Material Cost	■	■	■	■	■	■	■	■	■	■	■	■		■	■		■	■	■	■	■	19	36
	Market competition													■			■						2	
	Volume	■							■		■												3	
	Research testing and trialling costs				■	■	■																3	
	Programme			■					■	■		■	■				■						6	
Practicality	Production Issues							■	■			■											3	22
	Workability of the material				■	■	■	■	■	■				■	■		■		■		■	■	12	
	Practical knowledge of the material											■											1	
	Safety			■		■																	2	
	Procurement and Availability				■					■		■	■				■		■	■			7	
Quality	Quality			■							■												2	18
	Strength			■		■					■						■		■	■		■	7	
	Durability										■			■				■					3	
	Aesthetics	■		■	■		■		■								■						6	
Testing	Lack of Testing	■		■		■		■	■	■	■									■			8	14
	Types of testing			■			■	■			■		■										5	
	British Standards											■											1	
Risk	General Risk				■		■		■	■													4	12
	Insurance									■	■	■	■	■					■	■	■		8	
Marketing and Promotion			■	■	■				■		■		■	■			■	■					9	9
BREEAM				■					■				■				■			■			5	5
Government		■	■		■	■	■	■	■	■	■				■	■	■	■	■	■	■	■	17	17
Construction Culture	General Construction culture		■					■		■	■								■				5	19
	Mainstream use and Precedence	■		■					■	■													4	
	Change over time	■	■				■	■		■	■	■	■	■						■			10	
Supply Chain responsibility and perspective	Client driven/ Client Perspective		■	■	■	■			■					■			■				■	■	9	24
	Main Contractor Perspective			■											■								2	
	Subcontractor Perspective		■		■		■									■							4	
	Concrete Supplier Role																		■				1	
	Structural Engineering/ Designer perspective												■							■			2	
	New sustainable concrete company perspective																	■					1	
	Supply Chain Collaboration						■		■		■		■							■			5	
Other Sustainable approaches:	Concrete Wastage					■							■						■				3	7
	Cross Laminated Timbre (CLT)																■			■			2	
	Demolition																■			■			2	