UNIVERSITY OF CAMBRIDGE

Construction Engineering Masters

Construction Engineering Masters Dissertation Conference

15 September 2023

www.construction.cam.ac.uk/education/cem

@CEMCambridge

Construction Engineering Masters

The CEM programme was launched in 2011 with industry partner Laing O'Rourke to fulfil a shared vision of transforming the construction industry through innovation, education and technology.

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UNIVERSITY OF CAMBRIDGE

Construction Engineering Masters

Welcome

A warm welcome to current students, lecturers, supervisors, colleagues, alumni and special guests to the 2023 Construction Engineering Masters (CEM) Dissertation Conference. Today is an important event in the CEM calendar. It provides the opportunity for us to share with you the insights emerging from the latest research conducted as part of the CEM over the past year. As you will see from today's schedule, a wide range of thought-provoking topics will be covered.

The CEM programme is in a unique position to support research that is highly relevant to industry. Our students—who are experienced practitioners—draw on their own knowledge and experience of professions connected to construction to shape a relevant topic for enquiry. We connect students with academic supervisors from a range of disciplines (including engineering, sociology, finance, law and management) to provide guidance. We very much encourage this mixing of disciplines; what results is an insightful blend of subject areas and findings, all of which can help improve the construction sector in a meaningful way.

Today you will be hearing from the eleventh cohort of the CEM programme who are nearing the end of their research journey and are due to submit their dissertations in October. This cohort have the opportunity today to present and test their findings with a wider audience as they enter the final stage of completing their research.

The CEM journey for this cohort has undoubtedly been challenging. This group applied to join the in the middle of the COVID-19 pandemic. One of their residential weeks was switched to online delivery at the eleventh hour. So, it is a fantastic achievement that they are able to share their research with you today.

We have allocated some time for questions after each presentation and we encourage you to engage with the speakers to find out more about their research and its implications for the construction sector.

I hope that you enjoy the day and make the most of the opportunity to learn and network.

Thank you for joining us.

Dr Gavin Davies
CEM Course Director

How the conference will work

In-person Participation

The conference is being held at the West Hub, JJ Thomson Ave, Cambridge, CB3 0US. If you have requested parking you will be sent details separately.

The venue will open at 09:00 for registration, and the conference will commence at 09:30. The day is split into several sessions – each session containing 3 presentation slots. Each presentation slot is 15 minutes (10-minute presentation, 5-minute Q&A), with 5 minutes preparation/turnover time between presentation slots.

18 students from the eleventh cohort of the Construction Engineering Masters will be delivering presentations on their dissertation research, which spans a wide range of topics and themes. Audience questions are encouraged.

Online Participation

If you are joining the conference via Zoom please use the details below

Room East 1 (opening address, keynote and closing address)

- **To join:**
  https://cam-ac-uk.zoom.us/j/89120225658?pwd=UWlpRkFSa0lUaExpZENDMENsNm04dz09
- **Meeting ID:** 891 2022 5658
  Passcode: CEMDC2023

Room East 2

- **To join:**
  https://cam-ac-uk.zoom.us/j/87604138242?pwd=MDRRTlppZ3JpL2pUMkErbVVtVStFdz09
- **Meeting ID:** 876 0413 8242
  Passcode: CEMDC2023

Procedure

- *WHEN TO JOIN*
  Please consult the timetable provided to ensure that you **join the room during the allotted joining times** (during the start-of-day introduction and/or during the breaks between sessions) - attendees will not be admitted into a room once a session has started. Guests may leave during a session, but they will not be allowed to re-join until the start of the next session.

- *HOW TO JOIN*
  Using the joining details above, you will enter a waiting room.
  Please set your Zoom name to **display your full name and surname** so that you can be matched against the RSVP list and admitted into the conference room.

- *VIDEO AND MICROPHONE*
  By default, all attendees will enter the conference rooms with their **video off and microphone muted**. Please keep your microphone mute for the duration of the conference.

- *ASKING A QUESTION*
  During presentation slots you may use the chat function to submit your questions, privately, to the assigned marker (who will have 'host' after their name). Please ensure that you use the drop-down menu to change the recipient from 'everyone' to '…(host)'. Time permitting, the host will then read your question on your behalf.

UNIVERSITY OF CAMBRIDGE
Construction Engineering Masters

West Hub
JJ Thomson Avenue, Cambridge, CB3 0US

Zoom
Meeting ID: 891 2022 5658; Passcode: CEMDC2023

DISSERTATION CONFERENCE

Friday 15 September 2023: In person and online

Please note:
Student presentations are being marked, so:
1. We ask that all presenters and attendees keep their microphones and videos turned off - unless called upon by the markers.
2. We will not admit anyone into the room once a session has started - note the entry opportunities outlined below.

	09:00	-	09:30	Registration / Enter Zoom Room	Enter East 1
Session A1	09:30	-	09:40	**Dr Gavin Davies -** CEM Course Director Welcome	
	09:40	-	10:00	**Keynote Speaker: Prof. Lord Robert Mair CBE FRS FICE FREng** *Education and skills for the construction industry.*	
	10:05	-	10:20	**Edel Power** - Project Engineer, Laing O'Rourke *Carbon-reducing construction methods in Infrastructure.*	
	10:20	-	10:25	Turnover time for next student to prepare	
	10:25	-	10:40	**Jimmy Barratt-Thorne** - Associate Director, WSP *The embodied carbon of bridge substructures.*	
	10:40	-	10:45	Turnover time for next student to prepare	
	10:45	-	11:00	**Matthew Christopher Chandler** - Senior Engineer, Stantec *What factors influence the quality of the work-integrated learning aspect of the Degree Apprenticeship? Perspectives from apprentices in the construction industry.*	You will not be admitted into a room once the session has started.
	11:00	-	11:30	COFFEE & TEA BREAK (Main foyer)	Enter East 1
Session A2	11:35	-	11:50	**Lewis Evans -** Water Sector Lead, South Australia, Mott MacDonald [Presenting online] *Within current projects in the water sector in England and Wales, what are the barriers to consultants reducing whole life carbon performance in the design stage?*	
	11:50	-	11:55	Turnover time for next student to prepare	
	11:55	-	12:10	**James Hammond** - Project Manager, Feltham Resignalling, Atkins / SNCL *Failures in project delivery; determining factors that influence the deviation from project delivery best practice.*	
	12:10	-	12:15	Turnover time for next student to prepare	
	12:15	-	12:30	**Andrea Caristo** - Associate Director, AECOM *On the existence and impact of the "value-in-use" offer on the business and organizational models of professional service firms: the case for engineering consulting firms.*	You will not be admitted into a room once the session has started.
	12:30	-	13:40	LUNCH (Main foyer)	Enter East 1
Session A3	13:45	-	14:00	**Grace Newey** - Digital Transformation Specialist, Atkins *Factors that contribute to the challenges of digital adoption. Analysis of differing perceptions between white-collar and blue-collar roles.*	
	14:00	-	14:05	Turnover time for next student to prepare	
	14:05	-	14:20	**Leon Frylinck** - Principal Tunnel Engineer, Jacobs *Situational influences on decision making and project performance.*	
	14:20	-	14:25	Turnover time for next student to prepare	
	14:25	-	14:40	**Sven Heuten** - Head of Improvement & Innovation (Infrastructure), Sir Robert McAlpine *The impact of procurement on the adoption of collaborative planning on Highways Projects.*	You will not be admitted into a room once the session has started.
	14:40	-	14:55	COFFEE & TEA BREAK (Main foyer)	Enter East 1
				Examiner adjudication time	
	15:00	-	15:20	**Closing address**	
	15:20	-	16:30	DRINKS RECEPTION AND NETWORKING (Main foyer)	

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	09:30	-	09:40	**Dr Gavin Davies -** CEM Course Director Welcome	
	09:40	-	10:00	**Keynote Speaker: Prof. Lord Robert Mair CBE FRS FICE FREng** *Education and skills for the construction industry.*	
					Enter East 2
Session B1	10:05	-	10:20	**Rebecca Bleeze** - Associate, Stantec *Unknown Unknowns: Practice Post Pandemic.*	You will not be admitted into a room once the session has started.
	10:20	-	10:25	Turnover time for next student to prepare	
	10:25	-	10:40	**Marc Blancher** - Freelance Consultant *Digital Transformation in the AEC Sector: Navigating Design Team Interoperability Challenges.*	
	10:40	-	10:45	Turnover time for next student to prepare	
	10:45	-	11:00	**Jonathan Camp** - Senior Geotechnical Engineer, Harrison Group Environmental *Exploring a user-centred, data driven approach to the assessment of an existing cycling infrastructure network.*	
	11:00	-	11:30	COFFEE & TEA BREAK (Main foyer)	Enter East 2
Session B2	11:35	-	11:50	**Colin Morton** - Project & Engineering Manager, Freudenberg Performance Materials *Identifying Sustainable Development Opportunities in the Manufacture of Construction Products: Leveraging the Organisation's Existing Business Model.*	You will not be admitted into a room once the session has started.
	11:50	-	11:55	Turnover time for next student to prepare	
	11:55	-	12:10	**Thayananthan Baskaran** - Partner, Baskaran *Prefabricated Housing: How can we improve Customisation?*	
	12:10	-	12:15	Turnover time for next student to prepare	
	12:15	-	12:30	**Andrew Smyth** - Practice Manager, Atkins Limited *The impact of hybrid working on the professional development of early career engineers.*	
	12:30	-	13:40	LUNCH (Main foyer)	Enter East 2
Session B3	13:45	-	14:00	**Nicholas Povey** - Project Technical Lead, Laing O'Rourke *To what extent will the higher education and early careers system deliver the engineer of the future?*	You will not be admitted into a room once the session has started.
	14:00	-	14:05	Turnover time for next student to prepare	
	14:05	-	14:20	**Rachel Blair Winkler** - Construction Technology Executive *Wellbeing in construction: A mixed methods study on the prevalence of poor mental health, contributing factors and mitigation strategies.*	
	14:20	-	14:25	Turnover time for next student to prepare	
	14:25	-	14:40	**Thomas Oliver** - Associate, Atkins *Exploring collaboration within an equal partnership.*	
	14:40	-	14:55	COFFEE & TEA BREAK (Main foyer)	Enter East 1
				Examiner adjudication time	
	15:00	-	15:20	**Closing address**	
	15:20	-	16:30	DRINKS RECEPTION AND NETWORKING (Main foyer)	

The embodied carbon of bridge substructures.

Jimmy Barratt-Thorne

Associate Director

WSP

Climate change and the consequences are no longer a potential threat, but a reality that is only going to worsen unless global emissions are dramatically reduced.

Upon review of the existing literature on embodied carbon within bridges, it is not known in generalisable terms which elements are the most carbon intensive, or how much of the embodied carbon is attributable to the substructure and foundations. It is also not understood how much opportunity there is to reduce carbon at the concept or detailed design stages. The literature review also shows how there are significant variations in carbon emissions for the main materials used in bridge construction, including concrete and steel, that also contain varying projections for future decarbonisation.

This paper researches measures to decarbonise bridge structures, which are a carbon intensive element of infrastructure projects. Since we are in a critical period for carbon reduction, this research focuses on the embodied carbon lifecycle stage to reduce upfront emissions. To control the number of variables, a case study approach is used based on a real structure, whereby nine concept options are developed for differing substructure and foundation solutions, with additional efficiency measures explored at the detailed design stage. For each concept a schedule of materials is produced to quantify the embodied carbon using an in-house tool. This enables a quantitative analysis to compare and contrast the embodied carbon of the concepts, including a sensitivity analysis on the carbon conversion factors for various scenarios considering high or low carbon sources of concrete, steel, and aggregates. Cost data is also produced for the UK market, to enable a cost comparison with carbon.

The results of this research show that the substructure and foundations can account for approximately half of the embodied carbon within a bridge structure. Within the materials used, concrete is the most carbon intensive, followed by steel but also aggregates can make up a significant portion and unexpectedly in some instances result in piled foundations being preferred over spread foundations, due to savings in earthworks. It is the concept stage that is the most important to focus on for reduction measures, where it is found that some concept options have half the carbon of others, with savings realised through the use of reinforced soil walls and a reduction in foundation sizes. Whereas at the detailed design stage only savings of up to 20% are possible. Surprisingly, the results are found to be generally insensitive to the carbon conversion factors. Finally, carbon and cost are strongly correlated, and that designing with carbon consciousness should result in cost savings too.

Overall, this research will help designers make informed decisions about choosing an optimal solution for bridge substructures and foundations and shows that focusing on the concept stage can lead to significant savings in embodied carbon. The use of a sensitivity analysis shows how decisions can be made using broad assumptions that will remain valid in alternative geographical locations, as well as time.

Prefabricated Housing: How can we improve Customisation?

Thayananthan Baskaran

Partner

Baskaran

The object of this dissertation is to consider how we can improve the customisation of prefabricated houses. This is to overcome the perception that prefabricated houses are rigid, repetitive, and unappealing. This perception has partly resulted in prefabricated houses, despite their many claimed advantages, being a small proportion of the total number of houses constructed.

The method used to conduct the research for this dissertation was semi-structured interviews. These interviews were conducted with architects, engineers, manufacturers, and house buyers. These interviews were used to ascertain whether the proposals in the literature to improve customisation at the stage of design, construction, and use, were being implemented in practice. These interviews were conducted to also consider whether there were methods of customisation used in practice, which were not contemplated in the literature, but were effective.

The result of these interviews found that a platform design with a late decoupling point for customisation by the inclusion of optional components was an effective means of customisation. This depended on there being an adequate range of components that could be combined with the standard platform. The range of components available would determine the extent of customisation that could be achieved. In practice, there were a limited range of components that reduced the extent of customisation available. There were also limitations to the combinability of the components, as the component were often from a closed system.

The conclusion this dissertation draws is that steps should be taken to ensure the combinability of platforms and components. This would require guidelines to ensure an open system that allows for greater combinability. This open system for would also spur a larger range of components that can be combined with any platform or other components.

Wellbeing in construction.

A mixed methods study on the prevalence of poor mental health, contributing factors and mitigation strategies.

Rachel Blair Winkler

Construction Technology Executive

As research in professional wellbeing accelerates globally, wellbeing specific to the construction industry remains a comparatively under-researched area. More research is needed to understand the prevalence of poor mental health, contributing factors, and mitigating strategies. This research aims to fill these gaps, specific to construction.

The first phase of this study aims to quantify the prevalence of poor mental health in the construction industry. A systematic literature review of existing research was undertaken and registered with PROSPERO. Inclusion criteria were within 10 years and specific to construction, mental health, and prevalence. Out of 114 reviewed, 21 studies met the inclusion criteria. This study identified higher prevalence of anxiety, depression, suicidal ideation and severe psychological distress in construction workers compared to general populations by region. The findings of this systematic review help quantify the scope of the industry-wide problem and support the need for more focused research by region and professional profile.

The second phase of this study, informed by the systematic review, narrows from a global, multidisciplinary analysis to research focused on construction workers Tier 2 and Tier 3 contractors at major building sites in the UK. 40 semi-structured interviews were conducted at 5 different sites with two populations: office workers directly or indirectly managing site operations and on-site workers. The interviews were structured with two areas of focus: (1) stress, coping mechanisms and mental health awareness, and (2) workplace culture with a focus on joy, belongingness, and inclusivity. Data from the two areas of focus were analysed separately. Descriptive analysis was used for quantifiable data and Framework Analysis was used for open-ended questions. Descriptive quantitative analysis on focus area 1 identified that both populations experience moderate workplace stress on average; and coping mechanisms and mental health awareness vary by individual, not population. Framework Analysis on focus area 1 identified two main themes: (1) extrinsic, environmental stressors specific to construction impact individual wellbeing; and (2) intrinsic, individual stressors have a connection to workplace performance. Descriptive quantitative analysis on focus area 2 identified that both populations rated a strong sense of belonging at work, with differences in the contributing factors. The on-site worker population rated support from colleagues highest, whereas the office worker population rated support from their direct manager as highest. Both populations ranked support from the company the lowest. Framework Analysis in section 2 identified four main themes: (1) rich social connections drive a sense of security and belonging; (2) structured employer programs support individual employee wellbeing; (3) professional and personal wellbeing are inextricably intertwined; and (4) the distinctive nature of construction contributes to a sense of pride and joy at work. The findings of this study suggest there is an opportunity for clients, employers and the industry, as a whole, to evolve policies, procedures and mindset to improve individual wellbeing and reduce the prevalence of poor mental health in construction.

Digital Transformation in the AEC Sector: Navigating Design Team Interoperability Challenges.

Marc Blancher

Freelance Consultant

The digital transformation of the architecture, engineering, and construction (AEC) sector is hindered by interoperability issues, impeding the full adoption of promising digital technologies, such as building information modelling, computational design, and design automation. These challenges affect the productivity of design teams. However, the existing literature provides little understanding of how AEC companies navigate software interoperability challenges. The sector's distinct nature of siloed organisation, multidisciplinary collaboration, and project-centric focus underscores the need for targeted research. This research delves into this gap by interviewing 14 design team managers from major AEC companies, using the constructivist grounded theory.

The research highlights how AEC companies apply the established strategies of single-sourcing and multi-sourcing specifically, influenced by software interoperability challenges, during their digital transformation. Single-sourcing uses just one software vendor. This approach reduces interoperability challenges. However, it also increases vendor dependency and limits flexibility to the functionalities of that specific vendor. On the other hand, multi-sourcing involves multiple vendors. This strategy allows companies to select the best software tools for their needs, offering greater flexibility. However, it demands deep expertise in organisational interoperability. Companies must build robust information and knowledge management systems for effective organisational interoperability. Additionally, they should establish standardised data transfer and design processes to achieve software interoperability expertise.

The research highlights AEC firms' strategic choices during digital transformation, emphasising the significance of mastering organisational interoperability. However, the conclusions of this qualitative study are based on a UK sample, potentially limiting its representativeness and broader applicability. Future research could expand geographically and quantitatively to better understand global software interoperability challenges in the AEC sector.

Unknown Unknowns: Practice Post Pandemic.

Participatory Action Research to identify how tacit knowledge can be stored as organisational knowledge to empower early career structural engineers' retrieval.

Rebecca Bleeze

Associate

Stantec

Structural engineering is a discipline that trades upon employee knowledge to develop innovative solutions. To consistently deliver quality projects, organisations share explicit knowledge amongst their teams using digital libraries and subscriptions. This enables early career engineers, henceforth referred to as ECEs, to research, learn and progress, regardless of location. The same inclusive practice is not currently implemented for tacit knowledge. The literature recognises that it is notoriously difficult to document and share this experiential form of knowledge widely. Instead, current practice allows it to develop organically in ECEs as they build personal experience through shadowing, project participation and interacting with office discussions. However, the natural flow of tacit knowledge has been disrupted.

The pandemic forced the construction industry to adapt to remote working. Whilst technology has advanced to accommodate a hybrid workforce, the way structural engineers approach tacit knowledge is unchanged. The reliance on proximity to transfer tacit knowledge is a significant problem as it creates siloed knowledge that cannot be readily retrieved and potentially lost through employee attrition. This impacts a structural engineering organisation's competitive advantage through project inefficiencies and a loss of innovation potential. By reducing office attendance, opportunities to shadow and be inspired by intriguing conversation have been diminished. The transfer of tacit knowledge has become disconnected and now must be actively sought out. This presents the conundrum; how will ECEs know who or what to ask when they don't know what they don't know?

This dissertation seeks to unravel these unknown unknowns and understand ECEs' perspective of tacit knowledge in practice post-pandemic. There are two primary aims of this study: to investigate through Participatory Action Research how ECEs retrieve organisational tacit knowledge in structural engineering and ascertain how this can be adapted to suit the social change in working milieu since the pandemic. Data for this study was collected in a single organisation with four structural engineering teams located in different UK offices. The population was split by career grade into three focus groups tasked with developing a proposal to address the research question: How can tacit knowledge be stored as organisational knowledge to empower early career structural engineers' retrieval? A quasi-experimental controlled trial of a digital template and platform to store and transfer tacit knowledge was conducted over three months. Groups of ECEs were split into those retrieving tacit knowledge from intra-office mentors, inter-office mentors, and the stored material. Qualitative data was gathered through a feedback questionnaire. The different group responses were compared to consider if storage and/or proximity affected the tacit knowledge transferred to ECEs. The initial focus group findings suggested the benefit of converting tacit knowledge to explicit was expanding ECEs' access to knowledge. Therefore, this dissertation created an organisational tacit knowledge library, categorised by engineering principles, to highlight unknown unknowns to ECEs approaching unfamiliar engineering tasks. However, the most striking observation to emerge from the data comparisons was how ECEs interacted with stored knowledge. The perceived value was not just access to explicit content, but the collection of experiences, contacts, and examples in a range of media. This dissertation demonstrates that this ensuing digital database empowers the early career engineers to personally interact with stored knowledge to develop their own tacit knowledge.

Exploring a user-centred, data driven approach to the assessment of an existing cycling infrastructure network

Jonathan Camp

Senior Geotechnical Engineer
Harrison Group Environmental

In 2021, 72% of car journeys in the UK were under 5 miles. Consequently, to reduce emissions and improve air quality, it is vital that there is a drastic increase in the number of people cycling and walking for everyday purposes. This step change will only occur however, following the provision of adequate cycling and walking infrastructure that provides a real alternative to cars. Without this, reliance on vehicles for short journeys will remain.

To increase bicycle use, it is fundamental to provide bicycle friendly environments. However, within our cities and urban areas, the planning of the infrastructure necessary for these environments remains a complex task. Without quality cycling networks that are coherent, direct, safe and attractive, urban environments across the world, will not see the large increase in cycling that is known to be required. Nevertheless, to plan and build this effective cycling infrastructure there is worldwide consensus that, high-quality, insightful data is needed. While methodology and approaches to cycle network planning vary across countries, the need for data remains consistent. To better understand existing cycling infrastructure networks, this study proposes a new methodology termed the 'Bicycle Infrastructure Network Assessment' (BINA) which has been defined quantitatively at the level of the user.

During this study, data collection was conducted over a three-month period across the city of Cambridge, UK. Then, linear acceleration and positioning data was extracted using a mobile phone application and built-in sensors. To complement this dataset, video footage was also captured from head-mounted three hundred- and sixty-degree cameras. Alongside the BINA, a preliminary Financial Impact Assessment was undertaken across the existing infrastructure network. This is anticipated to lay the foundations for realistic, data-driven economic assessment of faults identified within the network during this study. The data interpretation is used to explore the potential for this new methodology, and through the outcomes discusses potential methodological changes or additions. It also suggests future research opportunities and potential applications of the proposed methodology to support stakeholders' efforts to advance the planning, design, and implementation of urban cycling infrastructure.

On the existence and impact of the “value-in-use” offer on the business and organizational models of professional service firms: the case for engineering consulting firms.

Andrea Caristo

Associate Director
AECOM

The construction industry is characterised by the wide use of fragmented contracts which involve a multitude of stakeholders throughout an asset’s life cycle, where value is traded in time-bound exchanges between the asset owner and the wider supply chain. In such contractual arrangements, value is created by one party and transferred to another as a deliverable.

The increase in global competition, coupled with the need for better management of carbon footprint from the built environment and the opportunities provided by the latest technological developments in structural health monitoring, artificial intelligence and digital twinning provide the opportunity to shift the engineering consulting firms service offering from the traditional value-in-exchange towards participative long-term value co-creation.

The experiences and theoretical basis of the servitized offering and digital twinning of the manufacturing industry are used as the starting point to explore how value co-creation can be embedded within the construction industry, with a focus on engineering consulting firms. Through interviews with construction industry leaders within large multinational engineering consulting firms, this study explores the perceived technological and business preparedness to capture whole-life value co-creation opportunities, with a particular focus on the business model and organisational changes required to achieve the shift in the engineering consulting firms offer. The study identifies key motivators, enablers and potential areas of the business model and organisational structure which may need redesigning to move the engineering consulting firms’ offering towards outcome-based solutions and joint value co-creation with clients.

What factors influence the quality of the work-integrated learning aspect of the Degree Apprenticeship? Perspectives from apprentices in the construction industry.

Matthew Chandler

Senior Engineer

Stantec

The UK construction industry is suffering from a skills shortage due to its aging workforce, poor diversity, and competition from emerging sectors. It is expected to fail to meet the Construction Industry Training Board's predicted need for almost 220,000 new recruits from 2021 to 2025 and this may result in difficulties in being able to deliver its forecasted construction projects. It has been suggested that apprenticeships may be part of the solution for their ability to provide accessibility to opportunities for new entrants. The UK Government reformed its Apprenticeship Scheme in 2015, following recommendations made by the Richards Review in 2012. However, post-implementation, the construction industry has fared poorly, with completion rates at 45% and below average satisfaction rates for the quality of training provided. While there is substantial literature concerning the formal training element of the Apprenticeship Scheme (known as "off the job training"), the factors impacting the quality of the work integrated learning aspect of the apprenticeship are not as well understood. This exploratory research project sought to further the understanding of this aspect and collected data through a series of 20 semi structured interviews with Degree Apprentices studying Civil Engineering. After concluding the analysis, six themes emerged from the data as being impactful on the apprentice's learning experience at the workplace. These included: stakeholder involvement and support networks, compliance with apprenticeship scheme requirements, time or workload related impacts, adequacy and application of learning opportunities, facilitation of the apprentice's individual learning needs and the consistency of the apprentice's learning environment. This research project concludes by making recommendations for improvement based on the identified themes and discusses the limitations and potential areas of future research to improve the understanding of the work integrated learning aspect of the UK's renewed Apprenticeship Scheme.

Within current projects in the water sector in England and Wales, what are the barriers to consultants reducing whole life carbon performance in the design stage?

Lewis Evans

Water Sector Lead, South Australia
Mott MacDonald

Meeting the climate change goals set in international agreements, government policies, and commitments within the water sector industry is crucial to mitigate the impact of climate change to manageable levels. However, the construction sector in the UK is not on track to achieve its net zero targets. The purpose of the dissertation is to improve industry understanding of the barriers to consultants reducing whole life carbon performance in the design stage and the role played by contract incentivisation within the water sector in England and Wales. The study aims to identify which blockers are identified by designers in their current projects to reduce whole life carbon. The research has been structured thematically, and summarises previous research, knowledge gaps, and areas of disagreement in the existing research relating to the study. The study undertook qualitative semi-structured interviews to collect data from industry professionals from global engineering consultancies. The main themes identified in this study were firstly design consultants are followers rather than leaders and therefore inherently reactive rather than pro-active, secondly, traditional project constraints, such as time, cost, and quality, hamper designers' ability to focus on carbon reduction, thirdly there is a lack of confidence in carbon accounting accuracy, which undermines designers' capability to implement effective carbon reduction strategies, and fourthly, the perceived lack of power of designers to make a difference to meaningful change in the design stage. The conclusion of the study is that it is perceived that significant carbon reduction opportunities are being missed in current project delivery. The barriers to maximising these opportunities are complex and require organisational change within project delivery models and current incentivisation methods to be realised.

Situational influences on decision making and project performance.

Leon Frylinck

Principal Tunnel Engineer

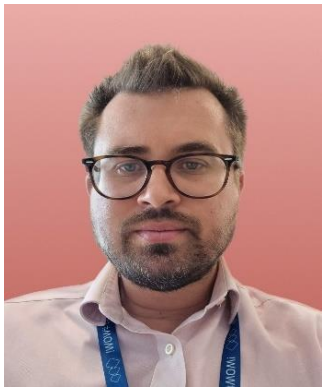
Jacobs

The prevailing challenges of project management, particularly within the construction industry, are rooted in the pervasive occurrence of budget overruns, time delays and failure to meet expected outcomes. Research has consistently shown that approximately 99.5% of projects experience budget overruns, delays and fail to deliver on anticipated benefits. Cognitive behaviours play a substantial role in decision-making across various contexts, indicating that they are not confined to specific locations or project scales. Despite this, the project management landscape, including large-scale projects, has shown minimal improvement over time. Consequently, it is acknowledged that initial project planning estimates often rely on non-comparable estimates derived from imperfect information, leading to flawed decisions and adverse impacts on project performance. These outcomes persist despite the perception within organisations that they are effectively delivering projects. Cognitive behaviours, influenced by situational context and emotional states, play a pivotal role in decision quality. The interplay between intuitive and reflective thinking further emphasises the intricate nature of decision-making.

This dissertation investigates the influence of situational context on decision-making and its subsequent impact on project performance. By employing the Critical Incident Technique (CIT), incidents relating to project performance and project management are examined in this study, to investigate the relationship between situational and contextual factors to uncover patterns, discrepancies, and correlations. Thematic analysis of these incidents demonstrated challenges posed by cultural diversity, stakeholder dynamics, time pressures and cognitive biases in decision-making processes. The study underscores the importance of recognising cognitive biases and their effects on decisions within culturally diverse, time-pressured, and uncertain project environments. It showcases how decisions influenced by cultural differences, stakeholder dynamics, and cognitive biases can result in suboptimal and, often, disastrous outcomes.

The study reveals that acknowledging and mitigating cognitive biases is essential for effective decision-making in complex project environments. It highlights the significance of open communication, interdisciplinary collaboration, domain expertise, and self-awareness in navigating these challenges. Ultimately, the research provides valuable insights into understanding how situational context can shape decision-making behaviours, impact cognitive processes, and influence project performance. By leveraging these lessons, organisations can strive to enhance decision-making processes and optimise project outcomes in a constantly evolving global landscape.

Failures in project delivery; determining factors that influence the deviation from project delivery best practice.



James Hammond

Project Manager

Atkins/SNCL

Success or failure of a project is the difference between what is expected of a project before completion, what is delivered at completion, and the observed performance once complete. Yet many projects fail; infrastructure projects are likely to be late or overspend. Addressing this is critical for future success of infrastructure projects. There are known project delivery features that significantly improve the reliability and performance of projects; best practices that can be implemented. Examples include that from professional bodies, for example the APM Body of Knowledge, and academia. This research project seeks to better understand the critical features (best-practices) of project delivery methodologies that are likely to deliver more successful outcomes, to what extent projects implement best practice in their delivery methodologies, and potential actions that could be implemented to improve delivery. This presentation will provide an overview of the background to the issue and present emerging findings from the survey element of the wider study, which will later encompass detailed feedback from semi-structured interviews.

The impact of procurement on the adoption of collaborative planning on Highways Projects

Sven Heuten

Head of Improvement & Innovation (Infrastructure)
Sir Robert McAlpine

The construction industry is frequently characterised by poor productivity, and projects regularly exceed their expected budget and programme. Numerous reports have listed reasons for this, including a fragmented industry and the prevalence of adversarial conditions.

Lean Construction has been identified as a different way of managing construction projects which promises to improve the performance of construction projects significantly. The Last Planner System™(LPS), frequently called Collaborative Planning (CP) in the UK Construction industry, is one of the first and most adopted Lean tools in the construction industry. It includes creating a joint programme to which all participating parties commit and are subsequently held accountable. This has been shown to increase programme reliability and, in turn, reduce uncertainty.

Studies have identified reasons for the limited adoption of CP. Procurement is listed as one of the key reasons, but less research has been conducted into the more detailed aspects of procurement that may present this challenge.

This study has identified key aspects of the procurement process used on Highways Construction Projects in the UK, which have provided positive and negative motivations for organisations to take part in CP. The first phase of the study identifies the critical steps in the procurement process by conducting interviews with participants from the three organisation types considered in this study: Tier 1 Contractors, Designers and Subcontractors.

In the second phase of the study, a separate group of interview participants from the same organisation types were asked about their positive and negative motivations for participation in CP based on the procurement process they experienced. The main drivers and the risk perception of the organisation types were subsequently analysed using the principles of economic game theory.

The interview data identified critical challenges in the current approach taken to procurement on Highways projects. These include establishing the project budget based on an immature design while simultaneously fixing the construction start and the open-for-traffic date for the project.

Although CP may provide a mechanism for overcoming the significant pressures on the project budget, the late involvement of designers for the detailed design phase and subcontractors to provide, advice for this process may contribute to the risk of the project exceeding the budget and overrunning the programme.

Using the game theory principles for analysis, the interaction between the positive and negative motivations for CP participation for the different organisation types is illustrated. While both the project and the individual organisations may benefit from further CP deployment, designers and subcontractors perceive the unclear contract scope with accompanying contract conditions as a significant risk to the performance for their organisation. In addition, the Tier 1 contractors perceive their requirement for predictability as an additional challenge to seek further improvements.

Identifying Sustainable Development Opportunities in the Manufacture of Construction Products: Leveraging the Organisation's Existing Business Model

Colin Morton

Project & Engineering Manager
Freudenberg Performance Materials
Building and Construction Materials Division

The consequences of climate change and other contemporary sustainability challenges increase the demands on industry to develop and implement sustainable solutions. Sustainable development necessitates the management of an organisation's environmental and social responsibilities on an equal footing with its economic objectives. Although the construction sector remains a major contributor to the sustainability challenges facing the world today, the sector has so far failed to contribute to providing sustainable solutions. A myopic focus on economic returns can blindside an organisation's responsibility to promote sustainable social and environmental solutions. Risk adverse corporate cultures are apprehensive of the potentially disruptive consequences of sustainable commitments for the organisation's operations. This research investigates how the concept of business models can be used to identify areas for sustainable development that do not undermine the organisation's existing revenue generating capacity. The research uses a holistic, single case study research strategy to analyse the existing business model of a multinational manufacturer of construction products. A systems-thinking approach is used to create a visual representation of the company's business model in the form of a causal-loop diagram. The research aims to identify virtuous-loops, which are not directly part of the revenue generating mechanisms of the organisation, but which provide fertile opportunities for sustainable development using a process of business model innovation. The results identified a number of different virtuous-loops which can be sub-divided into three typologies depending on which of the value components of the business model construct they contain. Each typology offers a different potential for sustainable development. The research provides a straightforward methodology that assists industry to identify sustainable development opportunities within their existing operations, by providing clarity on what changes need to be made to the business model to generate sustainable solutions that do not adversely affect their current business activities.

Factors that contribute to the challenges of digital adoption. Analysis of differing perceptions between white-collar and blue-collar roles.

Grace Newey

Digital Transformation Specialist
Atkins

In the construction and engineering sector, digital transformation has emerged as a prevailing strategy among businesses, with the intention of enabling them to not just discover competitive advantage, but more importantly as a necessity to ensure that modern day organisations keep up with the demands of rapidly changing technology advances. The benefits of digital transformation are derived from the recording, collection, manipulation, and dissemination of data to enable businesses better insights into their projects and how efficiencies can be realised. The United Kingdom's construction sector is gradually embarking on the journey of digitizing its projects. However, certain sectors within this vast industry are lagging behind, most notably the rail sector, which has historically been slow to embrace innovation due to stringent operational constraints, governance and expectation placed upon it by government bodies such as the Office of Road and Rail (ORR).

Despite making significant strides, Atkins Signalling Business has not fully realized its digital transformation potential. This research seeks to dissect the factors contributing to these challenges, with a particular focus on the differences between its office based technical roles, in comparison to site based practical roles. It employs a multifaceted approach, combining a review of existing literature with primary data collection in the form of survey and interviews to identify prevailing trends and correlations. Among the key findings, the analysis underscores the pivotal role of perceptions, emotions, and competencies in shaping the digital transformation landscape across different demographic groups. Notably, one emerging theme centres around the interplay between skill erosion in site-based roles and the ongoing process of digitisation.

This project aims to analyse data collected from members of the Atkins Signalling Business, with the potential for that to be expanded upon as the research progresses, through follow up interviews. Better understanding the implications of the correlation between competencies in roles and digitisation could offer invaluable insights into optimizing digital transformation strategies, not only for Atkins Signalling Business but also for the broader construction industry. Ultimately, this research sets the stage for a more comprehensive understanding of the challenges and opportunities inherent in the ongoing digital transformation journey, paving the way for more informed decisions and strategies in the future.

Exploring collaboration within an equal partnership.

Thomas Oliver

Associate

Atkins

The construction industry is one of the largest sectors in the world economy. It is expected to continue to grow as the world recovers from the Covid-19 pandemic, grapples with upgrading aging infrastructure and looks to tackle the climate change crisis. However, the construction industry consistently trails behind in productivity performance, leaving over a trillion dollars of potential value lost due to inefficiencies and poor collaboration. Globally, the construction industry, particularly the UK, has long recognised the need to improve collaboration and has looked to partnering as a way of creating more effective teams and improve productivity. Latham, Egan and Farmer all produced stark assessments of the UK construction industry, stressing the need to tackle the fragmented and confrontational industry in order to improve efficiency and productivity. Consequently, one of the main recommendations from these reports, which was seen as key for improving general collaboration and therefore improving productivity, was for an increase in partnerships.

Current research suggests that collaboration within partnerships can be influenced via two types of practices, Engineered and Emerged. Engineered collaboration can be seen as the 'top-down' management approach, utilising formal collaboration workshops, joint charters, and other such techniques. Whereas Emerged collaboration is developed from the 'bottom-up', as a consequence of individuals who develop relationships, share values and trust. Predominately, research to date has concentrated on how these two practices influence collaboration within partnerships based on a 'parent-child' relationship. This research aims to study this association in the context of two equal partners. A Joint Venture (JV) between Atkins and Mott MacDonald was used as a live case study to explore the factors that influence collaboration within an equal partnership.

To achieve this overarching research aim, the first step required identification of the informal collaboration network within the JV using email audit logs. The network was then analysed using Social Network Analysis (SNA) techniques to establish the Density, Degree Centrality and Betweenness Centrality of the network. The findings from the SNA were then explored further through targeted interviews.

Results from the SNA highlighted where different collaboration practices are prevalent within the JV, follow up interviews then elaborated on the perceived effectiveness. A combination of Engineered and Emerged collaboration techniques was cited to be required for equal partnerships to be successful. However, in the case study example, the aspiration of maintaining equality within the JV may have overshadowed the need for a controlling mind, a theme that warrants further research.

To what extent will the higher education and early careers system deliver the engineer of the future?

Nicholas Povey

Project Technical Lead

Laing O'Rourke

This research aimed to gauge the effectiveness of the higher education and early careers system in delivering the civil or construction engineer of the future. The climate emergency and the rapid pace of technological change in our world are factors that mean a different skill set is required of civil and construction engineers to previous generations. In the UK, the profession requires more engineers annually than what is output from national HEIs today, so the industry not only requires a more diverse set of engineers, but also more of them.

This problem is important because, without effective implementation from the earliest stage of an engineer's education, the skillset of construction engineers will be asynchronous to the needs of society in the future. The industry will continue to lag others in its productivity and innovation performance, and young people will not be drawn to the subject at university.

The problem was explored via a thematic analysis of 'future vision' engineering publications to determine the main evolutionary points. These future visions were tested for their level of adoption in degree programme curricula and engineering firms via thirty semi-structured interviews across three populations: academics, recent graduates, and managers of recent graduates. The responses from each group were tested against each other to identify gaps in the HEI and early careers system.

Carbon-reducing construction methods in Infrastructure

Edel Power

Project Engineer

Laing O'Rourke

As the need for tackling the environmental impacts of our actions becomes increasingly urgent, the built environment sector faces the significant challenge of reducing its emissions to net zero. As one of the world's largest emitters, research on the environmental impact of the built environment and construction has gathered pace in recent years. Detailed life cycle assessments demonstrate the carbon credentials of critical construction materials and energy usage. However, it is not clear if the industry engages and benefits from this research.

This study aims to establish a baseline for carbon reduction knowledge and activities within the infrastructure construction industry. The study followed a mixed-method, sequential approach. The first research element was a survey circulated to professionals within the infrastructure construction sector. Though some sectors and professionals reported that carbon influenced project decision-making, the overall response was mixed. Respondents did not believe that carbon management processes were standardised across the industry or organisations, which leads to complications when calculating environmental impacts. Life cycle assessment scored relatively high for the environmental impact assessment method. Outputs from the survey informed the next phase of research; a quantitative assessment of carbon used to construct an infrastructure maintenance structure.

The environmental impact of this structure was calculated using the Life Cycle Assessment technique. Measured data was extracted from the as-built records of the structure and used in this assessment. A comparison of two alternative construction methods for the structure was also assessed using equivalent data. This enabled further investigation of the whole life cycle impacts of the different construction methods and temporary works used within each scenario. The outputs gave clear indications of preferred construction methods for reducing carbon emissions. However, from the as-built records, it is evident that not all carbon-reducing methods were used within this construction phase.
To understand how this information could be better used within the industry, a series of semi-structured interviews were carried out with key decision-makers from infrastructure construction backgrounds. The interviews examined the role carbon plays within projects today and investigated how this role can evolve to become the leading criterion for decision-making on future projects.

This study aims to provide construction professionals with increased knowledge of the environmental impacts different construction methods can have. It also provides decision-makers with strategies to enable carbon to become a key influencer when faced with challenging decision-making within infrastructure construction.

The impact of hybrid working on the professional development of early career engineers.

Andrew Smyth

Practice Manager
Atkins Limited

The pandemic has changed how office workers in the UK approach the workplace. It accelerated some trends, with hybrid or home working now more prevalent than before the pandemic. While this new approach is often cited as beneficial to both employers and employees, is it impacting the professional development of early career engineers? Using the case study of the UK section of a global engineering consultancy, the perceptions of three different cohorts at different stages of their careers are explored through semi-structured interviews to understand their experiences regarding their work location and how their colleagues' attendance impacts their professional development.

The research showed that the formative years of the participants' careers played a significant role in their approach to how often they attended the office, with the older cohorts attending the most and the lockdown group the least. This led to them all being content with their work-life balance but, for the more recent cohorts, unaware of what they were missing in their professional development. Communication has predominantly moved to the virtual world, and ad hoc conversations with senior colleagues have been reduced. This has resulted in less tacit knowledge exchange from senior colleagues to early careers, such as how to engage with clients or overhearing senior colleagues discussing challenging situations.

The approach to office attendance has changed, and it is unlikely to ever return to pre-pandemic levels. The most successful organisations will adapt to this to maintain strong professional development and ensure their employees are satisfied in their positions so they can retain staff and make them attractive to prospective employees. This should involve greater structure between early careers staff and their mentors, including a more concerted effort to connect them during the graduate intake period.