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PROMOTING HEALTH AND SAFETY ON UK CONSTRUCTION SITES USING LEAN CONSTRUCTION STRATEGIES

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ABSTRACT

Poor health and safety (H&S) conditions in the construction industry are linked to ill-defined social and economic factors. To mitigate poor construction H&S performance, it has been widely recommended that Lean Construction (LC) strategies be adopted. Existing literature shows a strong correlation between implementing LC and improving construction H&S performance. However, limited research utilises qualitative research based on primary data to understand the perspectives of experts with real-world experience on the LC/H&S relationship. To address this gap, we conducted a novel study interviewing eight highly experienced LC experts to gain insights into how LC can enhance H&S in construction projects. Going beyond theory, we conceptualised a model linking key LC methods to root causes of H&S accidents to enable tangible improvements. This model intends to guide construction professionals in adopting and implementing LC strategies to foster safer construction workplaces. Our findings affirm and extend prior research by emphasising the efficacy of LC methods in improving H&S performance in construction projects.

KEYWORDS

Lean Construction, Health and Safety, Accidents, Waste, Flow

INTRODUCTION

Construction is one of the most dangerous industries, with a higher death rate among its workers (National Safety Council, 2023). This does not include fatalities from suicide – of which this industry also has one of the most. Accidents in this industry often result in death or serious injuries. Every year, a significant percentage of employees are temporarily or chronically disabled due to injuries sustained on construction sites (Health and Safety Executive, 2023). According to the United States Bureau of Labor Statistics (2021), the annual number of deaths in the construction sector in 2020 was 1,008, which accounted for 21% of all deaths among US workers. In Great Britain, Construction-related fatal injuries jumped

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by 55% from 29 to 45 in the 2022/23 reporting year and it remains the sector with the highest number of deaths, according to the Health and Safety Executive (HSE, 2023). The most common types of fatal accidents in the United Kingdom (UK) in 2022/23, as reported by the HSE, are as follows:

- Falls from a height.
- Struck by moving object.
- Struck by moving vehicle.
- Trapped by something collapsing/overturning.
- Contact with moving machinery.

Construction-related accidents lead to productivity losses and increased construction expenses due to project delays, employee absences, healthcare procedures, employee health coverage, legal costs, reimbursement costs, and recovery sessions. These social and economic losses have an overall effect on human well-being (Schaefer et al., 2008).For these reasons, several research studies have suggested various techniques and approaches to improve the Health and Safety (H&S) performance of the construction industry. Lean Construction (LC) has been among the key research themes to enhance the H&S aspects of construction. According to LC principles, accidents are causes of process waste in terms of duration, budget, and workforce productivity, which obstruct workflow and impact product quality. Therefore, from a productivity perspective, injuries must be avoided (Mitropoulos et al., 2007) As a rule of thumb in LC, it is essential to ‘stop production whenever it feels unsafe’. In addition, ‘Respect for People’ is a core principle in LC. Several studies suggested that implementing LC principles across worksites can offer an opportunity for construction professionals to improve the H&S of construction work environments (Salem et al., 2007; Antillon et al. 2019, Melo and Costa, 2023). At the same, it has been argued that a focus on H&S from an early stage in projects, using LC, can also help companies achieve their sustainability targets and objectives (Emuze and Smallwood, 2013; Sarhan et al., 2021) and improve project value delivery (Gomez et al., 2020). This paper investigates the value of LC in tackling H&S concerns, specifically the root causes of construction project worksite accidents.

During the past two decades, the efficacy of LC practices towards enhancing H&S has been a source of considerable discussion. However, the topic has been primarily investigated for individual LC methods with limited investigations on the conceptual relationship between LC and H&S. There is little known about how LC tools and techniques could actually help to improve H&S performance on construction sites. The novelty of this study is through its distinctive methodological approach, which aims to inductively explore professionals' knowledge, opinions, and observations to unfold a phenomenon and pinpoint the link between LC and H&S. The paper contributes to knowledge and practice by providing a better understanding of the value of LC in reducing common construction site accidents. The paper is structured to start with a background section, followed by the methodology and the rationale behind the choice, the results, and closing with the overall discussions and conclusions.

BACKGROUND AND RESEARCH OBJECTIVES

An occupational accident is an unexpected event that leads to personal harm or illness, damage to assets, resources, equipment, the environment, or any impact on business opportunities (Hughes & Ferrett, 2012). The nature of construction activities, fluctuations in workplace conditions, climate impact, construction materials, and the constant need for mobility are among the challenges linked with construction worksites (Perttula et al., 2003).

As a result of such circumstances, employees are more likely to be engaged in various types of injuries.

Numerous studies have been conducted to identify the various causes of workplace accidents in the construction industry. Defects and engineering issues can introduce potential hazards, which can stem from inaccurate design or execution flaws (Bellamy et al., 2008;). Weak planning and supervising, poorly maintained worksites, and lack of expertise within the workforce are among the project management-related causes of accidents (Bellamy et al., 2008). Moreover, human-related issues such as the psychological state, training, physical and emotional abilities, and motivational factors, are among the key causes of accidents (Bellamy et al., 2008; Kletz, 1993; Sawacha et al., 1999). Administrative failures and the lack of implementation of H&S standards are also contributing factors (Toole, 2002). Overall, these findings highlight the multifaceted nature of construction-related accidents and the need for a holistic strategy that encompasses management, training, compliance, and a safety culture.

One of the fundamental concepts of LC is to constantly optimise operations to reduce waste, such as non-value-adding activities and other interruptions within the flow of operations. It is well established that reliable workflow in construction operations cannot be achieved without safe work practices. Hence, every event that can impact employees' well-being and obstruct the flow of value-adding activities can be viewed as a 'source of waste' that should be eliminated (Sarhan et al., 2018). Accidents often lead to a variety of consequential wastes, lower efficiency, economic losses, and project delays. Therefore, workplace H&S management can minimise the adverse impacts of accidents such as loss of work time and compensatory payments (Jang & Kim, 2007). Aside from the productivity perspective, a key aspect of LC is promoting 'respect for people' (Emiliani, 2008; Liker, 2011; Korb, 2016) and incorporating ethical responsibility towards maintaining employees' physical and mental health (Rother, 2010; Akers, 2011; Gomez et al., 2020). Therefore, from a theoretical standpoint, LC and H&S are well-aligned and interrelated. It is already well-established that the effective application of LC can promote H&S in the workplace and minimise accidents. However, this study contributes to knowledge by addressing the following research objectives:

- Identifying the most common causes of accidents on UK construction sites and investigating their root causes,
- Exploring the relationship between LC and H&S performance,
- Providing practical insights from industry experts on the barriers and enablers of adopting LC for improving H&S performance on construction sites, and
- Developing recommendation for construction firms and professionals on how LC can be used to tackle these identified issues.

Several LC methods have the potential to improve H&S performance in construction projects. For example, the Last Planner System (LPS) can enhance workplace safety by empowering employees, aligning tasks with individual abilities, and promoting collaboration. Through pre-construction hazard assessments and regular monitoring, it proactively addresses potential causes of accidents, including ineffective practices, anxiety, and poor cooperation (Saurin et al., 2001; Sacks et al., 2005; Leino and Elfving; 2011; McHugh et al., 2021). Another example is the 5S method, which emerges as a potent safety tool by fostering a clean and organised workspace, enhancing comfort, and effectively managing resources. It directly addresses potential causes of accidents such as bottlenecks, inadequate work conditions, and workplace risks like slips, falls, and operating in narrow spaces (Ng et al., 2012). Visual management has been shown to be instrumental in advancing workplace safety through improved visibility, risk management, and clear warning signals. It directly addresses potential causes of accidents by enhancing communication, strengthening monitoring and scheduling, fostering site expertise and shared understanding, and promoting compliance with legislation. This proactive approach minimises the risk of accidents arising from weak communication channels, inadequate monitoring, lack of expertise, misunderstandings, and faulty decision-making (Melo and Costa, 2023). Other lean approaches for reducing onsite accidents include the use of standardised work (Mollo et al., 2019), Five Whys (Leino and Helfenstein, 2012), leading performance measurement indicators (Ng et al., 2012), Kanban (Jang and Kim, 2007), prefabrication and supply-chain management (Arbulu et al., 2005; Adekunle et al., 2023), BIM (Etges, 2020) and unmanned aerial systems (Melo and Costa, 2023).

METHODOLOGY

As indicated earlier, the main purpose of this study is to investigate how the application of LC can enhance H&S performance on construction sites. An inductive approach for qualitative data analysis was adopted in this study to gain a better and more practical understanding of the relationship between LC methods and H&S performance. Semi-structured interviews were conducted with eight UK industry experts in the field of LC. These experts were selected based on their extensive experience and expertise in implementing lean practices in construction projects. A snowballing technique was adopted, where each expert was asked at the end of every interview to recommend the next interviewee with relevant expertise and knowledge. Snowball sampling is an effective research method that is commonly used in social science research when the population under investigation is either hidden or difficult to reach (Browne, 2005; Waters, 2015). Table 1 provides details about the selected experts in terms of their profiles, years of relevant experience, and current work location. Interviews were conducted online and recorded for data analysis purposes after taking consent from the participants. Each interview lasted for about 30-45 minutes. The qualitative data collected through these interviews were analysed using thematic analysis (Braun and Clarke, 2006), aiming to identify patterns, themes, and key factors that contribute to the intersection of LC and H&S performance. A qualitative data analysis software (i.e. NVivo) was used to support with data coding and analysis, following the guidelines provided by Sarhan and Manu (2021).

Table 1: Interviewee Details

Expert no.	Professional's profile	Work experience	Work location
E1	Lean Construction Consultant	20 Years	Global
E2	Head of Project Planning	11 Years	UK
E3	Lean Construction Leader	19 Years	UK
E4	Lean Practitioner	8 Years	UK
E5	Productivity and Performance Manager	32 Years	Europe
E6	Senior Project Manager	28 Years	UK
E7	Chief Executive	46 Years	UK
E8	Director of Lean Consultancy	18 Years	Global

The choice of semi-structured interviews allowed for a flexible and systematic exploration of the experts' insights, experiences, and observations. The interview questions were designed to elicit detailed responses regarding specific lean tools, methodologies, and practices believed to influence H&S performance in construction. Four main open-ended questions were used for this purpose, as follows:

- **Q1.** What are the most common H&S problems / issues on construction sites?
- **Q2**. What are the main causes of these accidents or related H&S problems?
- **Q3**. How can lean construction help to improve H&S performance in construction?
- **Q4**. Which Lean construction (LC) tools or strategies could be used to address H&S issues in construction projects, and how?

RESULTS

In this section, the outcome of the thematic analysis of the collected data is provided. Four themes were identified based on the responses of the interviews. Two were related to H&S in construction and two were focused on their views on the interrelationship between LC and H&S. The following sub-sections present the results of the four identified themes.

COMMON H&S ISSUES ON CONSTRUCTION SITES

In order to set the context for the interview, the experts were asked about their experience with H&S and what they perceive as the most common H&S issues within the industry. Different types of H&S issues were highlighted. E1 and E7 found that falls from height are the most common, indicating that improper Personal Protective Equipment (PPE) compound this safety hazard. E2, E4, E5, E7 and E8 consider slips, trips and falls the most common issue. E2 also mentioned tiredness and fatigue, especially towards the end of the shift when workers may be making decisions that lead to injury. This aligns with findings of research by Turner and Lingard (2020) that investigated the impact of the physical demands of the construction work and (experienced and anticipated) bodily pain on the mental health and productivity of construction workers. E3 considered chemical hazards, obstructions on the site of vehicles, and the motion of people as major issues. While E4 mentioned that in the last 6-7 months of their work, utility strikes came up as a safety issue on construction sites. E6 stated that they are currently working on a highway project, and their team identified people-plant interference as the biggest hazardous factor.

CAUSES OF CONSTRUCTION SITE ACCIDENTS

The next question was intended to support the focus of the research on addressing the root causes of accidents. Therefore, the experts were asked about their views on the causes of site accidents. E1 indicated that poor planning is among the key causes of accidents. They stated that *"when the work methods are not agreed, the operational definitions are not established, and the first run studies are not done, these will cause on-site accidents".* E3 made a similar notion by suggesting that "*the most common cause of accidents is a lack of site planning because a lot of the hazards are identified within planning before workers go to the site…and to be honest, many people don't see these hazards individually*". E2 considered fatigue and lack of experience as causes of accidents, highlighting the role of human error in worksite accidents. This may also suggest the need for considering the implications of occupational stress and job-burnout on workers' safety performance (Sarhan *et al*., 2023). A similar finding was mentioned by E4, who indicated that personal behaviour is a major cause of accidents. They also explained that *"Employees know that what they're doing is wrong. They're taking the shortcut there, trying to do things quicker whether that is driven by targets or whether that's driven by intentionally, but it causes accidents*". E6 asserted that human behaviour is a main cause of accidents by saying that *"H&S starts at home, it starts with the individual. People forget having things in their minds and being under pressure to go out and do their day-to-day work, and they end up with safety issues. And this is where behaviour change is* *required".* It is important, though, to consider how project and organisational systems (e.g. contracts, payment methods and performance measurement systems) influence behaviours. E5 pointed out that lack of awareness and communication gaps play a major role in accidents. They added that untidy workplaces, unsafe working environments, and misunderstanding of information cause a large number of onsite accidents. E8 also identified poor communication as a key cause of accidents. E7 mentioned several general causes including employees behaviours, resources, activity management, planning and scheduling. They also indicated that among the causes is that *"people are reluctant to develop a plan at work, and when developed, they are reluctant to stick to that plan".*

THE ROLE OF LC IN IMPROVING THE H&S PERFORMANCE IN CONSTRUCTION

When it comes to the participants' views on the role of LC in improving H&S, E3 considered that a key concept in LC is about dissecting the activities into small activities and ensuring that each activity feeds into and adds to pre-identified value with the project stakeholders. The concept of flow is also essential and the interdependency between activities should not be overlooked. They asserted that the correct application of the Transformation-Flow-Value generation (TFV) concept can enhance H&S performance in construction. In addition, they indicated that the use of digital tools along with the Last Planner System (LPS) provides good results in terms of identifying the H&S hazards. They also highlighted that collaborative planning addresses H&S, as employees can know which machines/equipment are going to be used, the number of people working, and the motion of the machine and workers. E2 explained that a lean strategy ensures that the risk assessments and methods statements are delivered in time, so that employees can assess them for accuracy and workability. E4 and E5 see that visual management plays a big part in advancing H&S in construction, as it enables transparency and information sharing. As per E6, LC has a major effect on H&S risks. Based on their experience, proper planning can reduce unnecessary machinery movement by 50% and reduce carbon emissions, which are considered a hazard to the employees, surrounding people, and the environment. E1 described that *"there is a lot more to lean construction than the last planner, but that's how firms choose to write it up. The last planner has lots of planning conversations. The first conversation is about risk analysis and safety at construction sites. Also, 5S is very important as it will reduce trip hazards and so on, and another thing which I think would make an enormous difference going it would improve productivity along with reducing hazards".* E7 and E8 affirmed that collaborative meetings, daily briefings, and safety checks as part of a LC strategy can help to minimise H&S hazards. E7 provided an example by indicating that *"to identify potential areas for risk as part of activities, we ask a series of questions for each planned activity like: have you got the detailed design? have you got the resource or access? Safety considerations about materials, plant permits, and are they all identified?".* These are the necessary pre-conditions for starting any construction activity on site, which are conceptualised in LC literature as the seven flows needed to avoid the 'Making-Do' kind of waste (Koskela, 2004; Kraemer et al., 2007).

BENEFITS AND BARRIERS OF IMPLEMENTING LC TO IMPROVE H&S

A key objective of the interviews was to understand the correlation between LC and H&S performance to establish practical solutions for H&S improvement through LC. Therefore, the final group of questions focused on identifying the benefits and barriers of LC implementation to enhance H&S performance in construction projects. E1 mentioned that the focus of LC on value generation is a key benefit to H&S as LC will enable a systemic process for holistic improvement considering the complexity of construction systems. E2 indicated that *"the way you plan your work better through LC means that you're eventually improving H&S in a proactive way".* However, they shared their concerns that although the benefits of

LC have been evident over more than two decades, the market is not yet mature enough to understand the correlation between LC and H&S, due to the general perception that lean is about time and cost savings. E3 confirmed a similar notion that a key barrier is related to industry culture. They asserted that there is a lot to do in terms of embedding LC into current industrial practices and challenging the traditional perception of lean as a mere productivity enhancement tool. They also highlighted the importance of change management to influence current practices and provide evidence of the overlap between LC and H&S. E7 supplemented this view by stressing the problem of aging workforce that are usually resistant to changes. They emphasised the role of project leadership in promoting LC practices and demonstrating their benefits to the H&S of construction workers.

E4 highlighted transparency as a key strength of LC to help construction teams in minimising H&S hazards. They also indicated that the availability of data through LC tools can play a key role in establishing Key Performance Indicators (KPIs) for H&S monitoring and control. E5 considered the behaviour change as both a benefit and a barrier in terms of H&S improvement. They clarified that the ability of LC to influence behaviour towards a safer work environment can highly improve H&S performance of construction projects. However, they highlighted the risk of disruptions and confusion caused by new initiatives, especially in traditional industries such as construction, which might create safety hazards that impact the overall H&S performance. E6 provided an interesting view of the role of LC in using modern production methods in construction, such as modular construction and Just-In-Time, which are generally safer methods of construction compared to traditional hazardous heavy site activities.

In summary, the key benefits identified from the interviews were related to transparency, look-ahead collaborative planning, communication improvement, risk reduction, enhanced efficiency, modern methods of construction, and prioritisation of workers' wellbeing. On the other hand, the main barriers were related to the industry culture, behavioural aspects, time and cost of implementation, and standards and guidelines.

DISCUSSION

In exploring the complex relationship between LC and H&S performance in construction projects, our findings align with the acknowledgement that the causes of poor construction H&S are multifaceted. The expert interviews emphasised that LC practices directly counter several root causes of H&S accidents. LC can provide practical solutions to enhance H&S in construction projects. For example, collaborative planning emerged as a powerful mechanism fostering a shared understanding of construction activities (Pasquire and Court, 2013) and identifying hazards proactively. Daily huddles were identified as reinforcing safe procedures and enabling transparent discussions of risks. Visual management was recognised for its effectiveness in risk management by monitoring and eliminating hazardous actions on construction sites. These mechanisms collectively address human errors, oversight, miscommunication, and noncompliance – prevalent causes of H&S accidents on construction sites.

Importantly, LC practices were perceived not only as a group of tools and methods but as a catalyst for deeper cultural and systemic changes within the construction industry. They instil a sense of order, efficiency, and collective responsibility while flagging hidden risks. Participant experts highlighted the connection between LC and modern building techniques by emphasising their inherently safer nature. Utilising LC to create ecosystems centred on worker well-being was identified as an effective means to elevate the priority placed on accident prevention. As opposed to the traditional view of the workforce, which visualises individual employees conducting work along their linear career paths to create value for their organization, a workforce ecosystem is considered a more inclusive and integrated approach for strategically managing a diverse group of internal and external workers. The concept of a workforce ecosystem can be defined as "*a structure focused on value creation for an organization that consists of complementarities and interdependencies. This structure encompasses actors, from within the organization and beyond, working to pursue both individual and collective goals*" (Altman et al., 2021, p. 1).

Despite the evident benefits of adopting LC for improving H&S performance in construction projects, a key emerging barrier is the ingrained industry mindset that safety, profit, and efficiency represent competing aims. LC is often viewed as a set of solutions for waste reduction and productivity augmentation rather than an ethos enabling both safer and more productive job sites concurrently. Overcoming this scepticism requires leadership commitment, active worker engagement, and measurable H&S gains linked to LC adoption. The participants stressed that meaningful change management relies on demonstrating the compatibility of safety, profit, and efficiency within a LC strategy.

Based on the findings from the literature review and semi-structured interviews, we formulated a conceptual model that links the root causes of accidents, as reported in Haslam et al. (2005), with LC methods (see Figure 1). This developed conceptual model provides general guidelines to support H&S improvement in construction projects but is not intended to be a comprehensive approach. It serves as a steppingstone for further research and practical implementation by providing a framework for construction professionals, project leaders, and policymakers to enhance safety protocols by adopting LC principles.

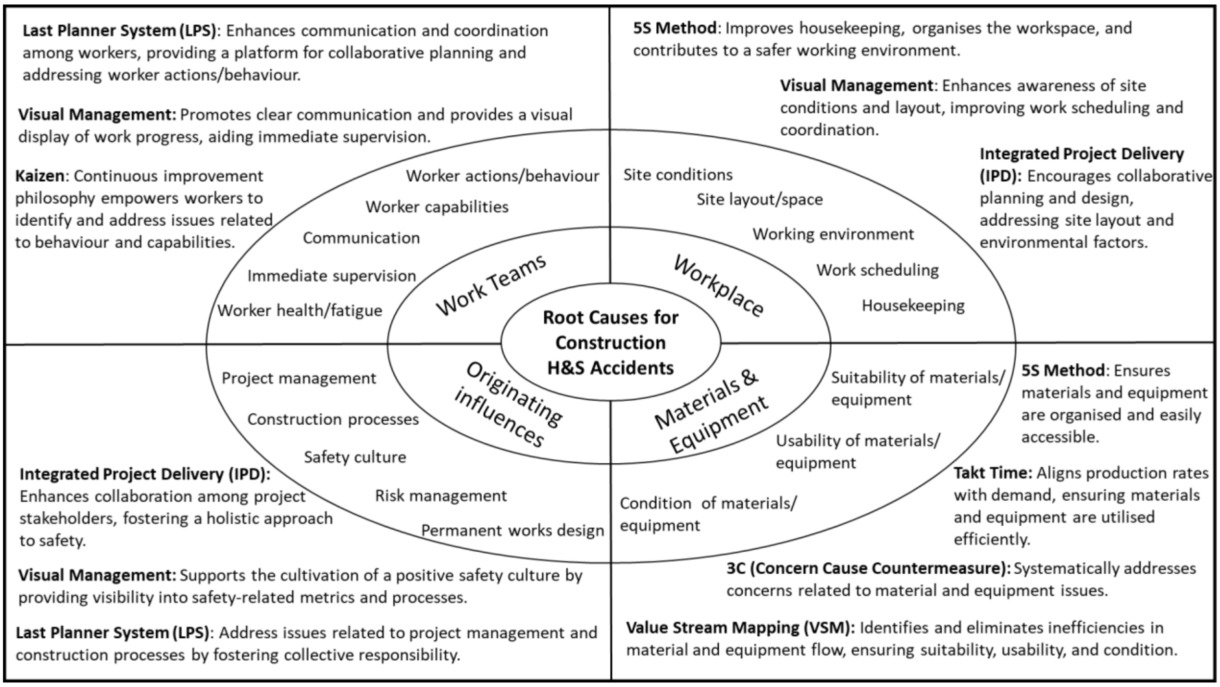

Figure 1: Conceptual model linking LC methods with root causes of construction accidents.

CONCLUSION

Poor health and safety performance remains a critical issue in the construction industry leading to injuries, fatalities, social and economic impacts. Prior research has connected LC principles of waste reduction and continuous improvement to enhanced safety outcomes. This study sought to elucidate the practical mechanisms underpinning this relationship based on insights from eight LC experts sharing their knowledge and suggestions from decades of first-hand industry experience.

Key findings reveal tangible methods by which the LPS, Visual Management, 5S among other LC methods proactively identify hazards while fostering orderly, transparent work ecosystems centred on worker wellbeing. Beyond isolated techniques, a lean culture and holistic systems approach was perceived to drive safer practices across different project dimensions. However, barriers related to industry culture and the prevailing views of cost, schedule, and safety as competing priorities persist. It is recommended that leadership commitment to worker-centric ecosystems is critical for successful implementation of LC to improve H&S performance.

The study concluded with a conceptual model that connects the root causes of onsite accidents with tailored LC countermeasures to provide actionable guidance for health and safety enhancement. The findings of this provide guidance to construction project managers and professionals on how to effectively use LC concepts, tools, and techniques to avoid or minimise the occurrence of accidents and related H&S problems on construction sites.

As an exploratory qualitative study based on interviews with a small purposive sample of industry experts, the findings are not meant to be generalisable without further validation. Quantitative examination is suggested to statistically correlate LC adoption maturity levels to H&S metrics such as incident rates and safety culture index. Comparative case studies of projects using varying degrees of LC methods would shed further empirical evidence on direct and indirect impacts on H&S outcomes. Future research avenues may also explore the longitudinal impact of LC adoption on the industry H&S performance and investigate the dynamics of such implementation within construction companies. Finally, further research is also needed to investigate how LC can help to tackle and minimise mental health issues in construction.

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