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LEAN IN ACTION: BZI'S INNOVATION PROCESS FOR STEEL ERECTION

Adam Hoots[1], Corinne Nalder[2], James Jeffs [3], Shima Clarke [4], and Alex Henry [5]

ABSTRACT

The steel erection sector of the construction industry continues to wrestle with persistent challenges, including safety concerns, workforce inefficiencies, and hesitance toward adopting new practices. This study explores how Building Zone Industries (BZI) aligns Lean Construction principles with innovative solutions to overcome these constraints efficiently and effectively. This case study of BZI's innovation process highlights two examples of unique, innovative, and proprietary BZI tools: the Unilink and Wide Swivel Carriage, both custom-designed to address the specific needs of a mega industrial manufacturing plant. These technologies were conceived from direct communication in the field, brainstorming, and testing. Central to BZI's approach is the culture of innovation which is focused on safety. Their core values drive the innovation process, which rapidly transitions ideas from conceptualization to deployment as examined in their innovation process. The findings highlight the role of collaborative leadership, workforce engagement, and iterative design in overcoming traditional barriers to Lean adoption. The study highlights the scalability of BZI's methods offering a replicable framework for integrating Lean practices across the broader architecture, engineering, and construction sector. By advancing both theory and practice, this study provides actionable insights for driving innovation and efficiency in steel erection.

KEYWORDS

Lean Construction, Steel Erection Innovation, Waste Reduction, Continuous Improvement, Workflow Optimization

INTRODUCTION AND LITERATURE REVIEW

The architecture, engineering, and construction (AEC) industry has long grappled with challenges such as safety risks, labor inefficiencies, and project delays, particularly in the high-risk domain of steel erection. Conventional methods frequently lead to excessive material waste, significant labor demands, and heightened safety risks, highlighting the urgency for innovative approaches (Hussin et al., 2013). Lean Construction principles emphasize respect for people by minimizing waste, optimizing workflows, and maximizing value, offering a systematic approach to tackling industry-wide challenges (Bajjou et al., 2019). However, implementation within steel erection has been uneven, often impeded by traditional practices and resistance to

[1] PhD Candidate and Instructor, Clemson University, Clemson, SC, USA ahoots@clemson.edu, https://orcid.org/0000-0002-0383-8437
[2] Project Engineer, Clayco, Reno, NV, USA corienalder@gmail.com, https://orcid.org/0009-0000-5302-6253
[3] Project Executive, Building Zone Industries (BZI), Cedar City, UT, USA jamesjeffs@bzi.com, https://orcid.org/0009-0007-8933-4638
[4] Professor and Interim Associate Dean of the College of Architecture, Art, and Construction, Clemson University, Clemson, SC, USA shimac@clemson.edu, https://orcid.org/0009-0006-4962-5089
[5] Project Manager, Industrial Project Innovation (IPI), Greenville, SC, USA alex.henry@ipi.build, https://orcid.org/0009-0001-1851-8866

change. (Al-Sudairi et al., 1999) This underscores the need for creative and collaborative strategies that not only incorporate Lean principles but also cultivate continuous improvement, innovation, and active workforce involvement.

LEAN CONSTRUCTION PRINCIPLES IN STEEL ERECTION

Lean Construction principles focus on respecting people, minimizing waste, and optimizing workflows to address systemic challenges in construction, particularly in trade contractor flow (Ballard, 1997). These principles are essential for enhancing, safety, quality, efficiency and overall value delivery on construction projects (Koskela, 1992).

Lean principles prioritize the inclusion of workforce input and empowerment to ensure solutions are practical and address real-world challenges. In steel erection, this means integrating feedback from field teams into tool development and process, which helps align innovation with the needs of both the workforce and project goals (Bajjou et al., 2019). This iterative approach encourages ongoing improvement, focused on prioritizing safety, enhancing quality, and increasing efficiency at every stage of the project. Applying Lean principles addresses industry demands by improving safety measures and mitigating inefficiencies often associated with current practice of rigging and offloading methods (Bajjou et al., 2019).

BUILDING ZONE INDUSTRIES (BZI)

BZI, a Utah-based, nationwide leader in steel erection, serves as the main subject of this case study on the transformative potential of Lean Construction. The people first and innovative culture at BZI has Lean principles embedded deep within. BZI distinguishes itself by developing proprietary tools that are not merely improvements to current practices but represent novel inventions addressing specific industry challenges.

BZI's culture of innovation stems from its commitment to revolutionizing construction while maintaining core values of trust, respect, and integrity. Safety remains the most important driver in brainstorming, prototyping, and engineering efforts to remove hazards and to safeguard workers. Most important is prioritizing the people closest to the work, with leadership emphasizing the importance of all employee's well-being, empowerment, and active engagement. Following the engineering of hazard removal is establishing quality through precision and reliability, followed by streamlining production processes to maximize flow efficiency (Building Zone Industries, n.d.). BZI identifies and prioritizes all decisions based on these three qualities: safety, quality and production efficiency.

CURRENT STEEL OFFLOADING AND ERECTION PRACTICES

Steel offloading and erection practices on large construction projects have traditionally relied on forklifts and cranes, each tailored to specific material requirements. Forklifts are employed when materials are appropriately stacked, positioned for easy access, and fall within the weight capacity for efficient lifting and transport. In comparison, cranes are required for handling oversized, heavier, or irregularly shaped materials. This requires specialized rigging and lifting methods to ensure safe and effective unloading. (Raynar & Smith, 1993)

Operating a crane requires detailed planning and strict adherence to safety measures, including assessing ground bearing pressure, addressing pinch points, and reducing hazards related to swinging loads. Furthermore, when steel erectors use cranes, it frequently involves multiple steps with workers performing similar tasks at ground level and elevated heights to secure and unsecure rigging, which increases the risk of safety incidents.

The current practice of erecting beams and trusses frequently involves a multiple vertical lift rigging procedure known as "Christmas-treeing." This method allows multiple members to be rigged and stacked vertically for simultaneous installation. In the United States, OSHA Subpart R 1926.753 strictly regulates this approach, limiting lifts to a maximum of five members per lift, each separated by at least two point one meters (seven feet), to prevent collisions or instability (OSHA, n.d.). Internationally, similar safety regulations exist; for instance, the UK's Health and Safety Executive (HSE) emphasizes avoiding tasks performed beneath suspended loads and strictly controls multiple-lift operations (HSE, 2021). Despite these standards, Christmas-treeing still presents inherent risks, such as load movement, employees positioned below suspended materials, and extended time spent working at heights. These global safety concerns highlight the value of innovative tools like BZI's Unilink and Wide Swivel Carriage, which could reduce or eliminate hazardous conditions associated with traditional methods. Adapting such innovations worldwide would require consideration of region-specific regulations, training requirements, and logistical challenges, emphasizing the need for adaptable solutions with broad applicability.

Figure 1: Christmas-treeing Method During Steel Erection

(Source: Steel Erectors Association of America, 2018)

INNOVATION IN CONSTRUCTION: DRIVING PROGRESS

Innovation in construction advances slowly, demanding substantial time, resources, and coordination. Unlike sectors with consistent innovation cycles, construction encounters distinct hurdles like diverse project demands, stringent safety regulations, and workforce integration complexities. On average, successful technical innovations in construction take approximately 38 months, 4,700 worker-hours, and $836,000 to develop, implement, and diffuse (Gambatese & Hallowell, 2011). BZI's innovation process was completed in a much timelier fashion, with roughly a similar investment.

Although the rate of innovation in construction equipment has accelerated over time, advancements are often driven by technological progress in adjacent industries rather than originating from within the sector itself (Arditi et al., 1997). Many advancements aim to incrementally refine existing tools and processes for better efficiency and safety. BZI demonstrates a different and unique approach to innovation. Leveraging a collaborative and agile development process, BZI quickly creates and deploys novel solutions specifically designed to overcome challenges in steel erection and building envelope construction. For example, the Unilink and Wide Swivel Carriage (WSC) attachment were developed and deployed within five months significantly improving safety, productivity, and efficiency on a mega industrial manufacturing plant in the Southeast United States. This approach demonstrates how targeted, field-driven innovation can change the conventional pace of progress in construction. Unilink transformed beam placement by mechanically fastening six beams horizontally and placing simultaneously, improving safety and productivity. Likewise, the WSC improved the way BZI offloaded material by eliminating the need for cranes, reducing labor requirements, and improved material transportation around site.

OBJECTIVE

The primary objectives of this paper are to analyze BZI's Innovation Process by examining the structured, iterative workflow that underpins the rapid development and deployment of BZI's tools. Furthermore, this paper evaluates the lean alignment by assessing how BZI's tools and methods align with the core principles of Lean Construction (Tzortzopoulos et al., 2020) and the Leanovation framework (Solaimani et al., 2019), including respect for people, waste reduction, and workflow optimization.

The study delves into the process of identifying field challenges, encouraging collaboration, and creating solutions such as the Unilink and WSC by examining how these tools were developed and fine-tuned to meet unique project requirements. The analysis showcases the cultural, technical, and operational elements driving BZI's success, providing a replicable model for Lean innovation across the AEC industry. Finally, this paper explores the alignment of innovation and Lean Construction principles by addressing the following research questions. How does BZI's innovation process align with and operationalize the principles of Lean Construction? What measurable impacts have BZI's innovations, such as Unilink and WSC, had on safety, quality, and operational efficiency?

METHODOLOGY

This research adopts a case study approach to analyze BZI's innovative processes and their alignment with Lean Construction principles on the mega industrial project, evaluating BZI's process through the lens of the Leanovation Framework. Case studies are a well-established research methodology for exploring complex, context-specific phenomena, particularly in construction innovation, where real-world applications provide critical insights (Yin, 2014). By focusing on the development and implementation of the Unilink and WSC attachment, this study investigates how BZI's iterative innovation process responds to constraints and drives improvements in safety, quality, and operational efficiency.

DATA COLLECTION AND ANALYSIS

This research employed a mixed-methods approach, integrating qualitative and quantitative data collection and analysis techniques. Over six months, researchers observed BZI's implemented innovation process at the large industrial manufacturing plant. Observations included noting operational efficiencies, safety protocols, workforce engagement, and real-time feedback mechanisms, providing insights into the practical application of Lean principles such as waste elimination and workflow optimization (Mays & Pope, 1995; Ballard & Howell, 1998). Semi-structured interviews were conducted post-innovation to further capture stakeholder perspectives on BZI's innovation processes (Kvale & Brinkmann, 2009). Interview transcripts and observational notes were analyzed qualitatively, employing swim lane process mapping techniques to visualize workflows and to clarify roles and responsibilities (Martin & Osterling, 2012; Waterhouse, 2021). Quantitative analysis compared safety, efficiency gains, and reductions in waste achieved through BZI's innovations (Unilink and WSC) against traditional steel erection methods.

LEANOVATION FRAMEWORK

The Leanovation Framework provided a basis for the researchers to evaluate how BZI's innovations aligned with key Lean Construction principles. This innovation process framework, based on the "Leanovation" model proposed by Solaimani et al. (2019), integrates core lean principles with innovation management strategies, emphasizing the development of a learning culture, collaborative structures, and iterative improvement processes to drive efficiency and value creation. BZI's approach to innovation reflects this framework by systematically addressing iron worker constraints and fostering cross-functional collaboration and learning from all stakeholders involved.

CASE STUDY RESULTS

BZI approaches innovation proactively, responding swiftly to field constraints that compromise safety, quality, or productivity, as demonstrated in the mega industrial manufacturing project, where traditional methods failed to meet specific design constraints. BZI's process begins with employee-driven ideas prioritizing safety, followed by quality and productivity, reflecting a people-first mindset. Rather than simply adding manpower or equipment, BZI systematically transforms these constraints into innovative, actionable solutions by addressing inefficiencies at their source.

INNOVATION PROCESS

BZI's structured innovation process showcases their ability to quickly move beyond adaptation and drive meaningful transformation through tools like the Unilink and WSC attachment. By engaging cross-functional teams and employing iterative design, BZI sets a repeatable standard for innovation in the construction industry.

Table 1: Stakeholder Involvement during Innovation Process

Field Team	Field Team Leadership	Company Leadership	Design, Engineering, and Manufacturing	BZI Innovation Process	BZI Innovation Process Description
X	X			Identify	Identify Challenges & Assumptions for Better Process
X	X	X		Brainstorm	Brainstorming and Prioritization
	X		X	Design	Design and Modeling
X	X		X	Collaborate	Collaboration with Field and Engineering Teams
X	X	X	X	Review	Prototype Review
			X	Manufacture	Manufacturing
			X	Factory Testing	Factory Acceptance Testing
X	X	X	X	Certify	Certification
X	X	X	X	Integration	Integration and Training
X	X	X	X	Feedback	Feedback and Productivity Improvement

IDENTIFY CHALLENGES AND ASSUMPTIONS FOR BETTER PROCESSES (IDENTIFY)

The Crew Members and the Field Leaders work together to identify challenges and those are quickly prioritized (within days) based on their influence on safety, quality, and operational efficiency. This stage ensures critical issues are resolved promptly, creating a foundation for solutions that improve project outcomes for all project stakeholders.

Unilink: BZI initiated its problem-solving process by closely examining the structural design of the mega industrial manufacturing project, which presented unique challenges that existing methods could not accommodate. Their previously developed Panel Table, designed to assemble beams and metal decking at ground level before lifting the entire panel system into place. This proved incompatible with the structural design of the project. As a result, BZI was left to rely on traditional methods, such as single-setting individual members or employing multiple-lift rigging. The mega industrial manufacturing project had site specific safety regulations that restricted Christmas-tree rigging to a maximum of three members per lift, more stringent than OSHA standard. This restriction impacted efficiency and drove the need for an innovative solution, setting the stage for the development of the Unilink.

Wide Swivel Carriage (WSC): A logistical challenge arose from the structural design and constrained on-site laydown space. BZI's analysis indicated that an additional crane would be required to offload material to keep pace with scheduled deliveries. To address this issue, BZI reviewed their material handling process revealing additional challenges with navigating the site and building layout, and extra time needed for rigging and material transport. These constraints led to identifying the need of a forklift attachment which would become the WSC.

BRAINSTORMING AND PRIORITIZATION (BRAINSTORM)

Over the course of weeks, ideas are generated and evaluated, with priority given to those that enhance safety, elevate quality, and improve efficiency. This phase of the innovation process allows the team to take the constraints to ideas.

Unilink: BZI's brainstorming phase tackled safety and efficiency issues tied to Christmas-treeing. BZI collaborated across leadership, engineering, and field crews to design a tool that could lift multiple beams safely and precisely, Unilink addressed safety risks such as working under suspended loads and at elevated heights. Furthermore, the workers in the field were able to place beams with precision, which increased their quality and productivity. The adjustability within the design ensured that the new piece of equipment could handle beams for this project's design and future project designs, making this a tool that will revolutionize the steel industry.

WSC: BZI focused on reducing crane dependency for offloading and maneuvering material around the project site. The team explored ways to enhance forklift capabilities by extending fork lengths to handle large trusses. However, the team quickly realized that elongated forks alone could lead to instability and potential failure. To resolve this, the design included a broader base to stabilize trusses and minimize deflection. Mobility within the site and building was a huge consideration. This roadblock led to the addition of a swivel feature to improve adaptability and ease of navigation. The swivel carriage was also designed to be customized and adaptable so not to be limiting to one model of forklift.

DESIGN AND MODELING (DESIGN)

The design and modeling phase is performed with Innovatech, BZI's sister company specializing in design and manufacturing of equipment. This phase is completed in just a matter of days, where transformation of the conceptual ideas for the Unilink and WSC into practical, field-ready innovations. Engineering and design teams collaborated closely with leadership and field crews to take field ideas to conceptual designs.

COLLABORATION WITH FIELD AND ENGINEERING TEAMS (COLLABORATE)

The development of the Unilink and WSC demonstrate BZI's collaborative process, which engages design, engineering, and field teams to ensure that the tools meet practical needs. Collaboration during this phase can take anywhere from days to weeks depending on the complexities associated and iterations necessary to provide a safe product. Leadership facilitates these conversations, field crews provide insights based on site observations, and engineering teams translate these ideas into economical and feasible designs. Leadership's involvement at this level helps everyone feel included in the innovation process.

PROTOTYPE REVIEW (REVIEW)

This stage involves close collaboration between field crews, field crew leaders, designers, engineers, and corporate leaders to ensure the prototypes met the practical demands of the job site while aligning to project priorities. Simulations are done to evaluate the functionality, safety, quality, and operational efficiency of the designs. Feedback loops play a critical role, enabling adjustments to be made in real-time to address any issues or enhancements identified during testing. This iterative review process ensured that the prototypes were functional and created in days.

MANUFACTURING (MANUFACTURE)

The manufacturing phase for the Unilink and the WSC marks a critical stage in transforming conceptual designs into physical tools, this process usually taking weeks to accomplish. This stage is spearheaded by Innovatech constructing each component utilizing high-quality materials and advanced fabrication techniques that emphasize durability, functionality, and align with safety standards. During this time, close coordination between BZI and Innovatech facilitates adjustments to address any emerging considerations or refinements, ensuring the final product meets the rigorous demands of the job site.

FACTORY ACCEPTANCE TESTING (FACTORY TESTING)

Factory testing is a critical phase in BZI's innovation workflow, requiring several weeks to ensure each tool exceeds safety and engineering standards. Initial assembly and setup are performed in a controlled environment designed to replicate project-specific conditions. This testing phase rigorously evaluates functionality, operational efficiency, and compliance with safety protocols. Engineers and field teams collaborate closely to identify refinements needed for consistent and reliable performance.

CERTIFICATION (CERTIFY)

The certification phase, which happens in days, ensures that each tool is fully compliant with safety and operational standards before being sent to the field for use. Certification involves coordination with Innovatech to develop precise load charts that detail the tool's capacities and operational limits. Critical safety measures and protocols are formalized, emphasizing hazard mitigation and safe usage practices. Owner's manuals, safety guides, and training programs are created to provide clear instructions for proper operation and maintenance. By prioritizing these elements, BZI reinforces its commitment to safety, reliability, and transparency, ensuring that every tool meets stringent industry requirements while empowering end users with the knowledge necessary for optimal performance.

INTEGRATION AND TRAINING (INTEGRATION)

The integration phase focuses on integrating newly developed tools into daily operations through in-depth field training led by the design and engineering teams. Over several weeks, crew members and operators are trained to safely and efficiently use the tools. These sessions are focused on understanding the tools' safety features, and how to utilize the new tool as a part of the job. During this time, the design team will remain engaged in the event additional safety, quality, or operational efficiency improvements can be made.

FEEDBACK AND PRODUCTIVITY IMPROVEMENT (FEEDBACK)

BZI demonstrates dedication to continuous improvement by incorporating feedback from the people closest to the work to enhance the tools and processes. Open collaboration between leadership, design teams, field crew leaders and field crews foster an environment of acceptance, which ensures that innovations like the Unilink and WSC adapt effectively to specific project needs. This iterative approach optimizes BZI's innovation process that produces solutions to resolve immediate challenges yet remain flexible for future applications.

CONCLUSION AND FUTURE RESEARCH

This study concludes that BZI innovation process aligns with the principles outlined in the Leanovation framework. By prioritizing safety, quality, and operational efficiency, BZI has demonstrated a robust, iterative approach to innovation. Grounded in field observations, ongoing feedback, and semi-structured interviews, this study shows how BZI's innovation process has yielded multiple transformative tools that advance Lean Construction principles. For The Unilink and WSC attachment, two of their most notable innovations for the mega industrial manufacturing project, effectively address key industry challenges while delivering substantial improvements in safety, quality, and operational efficiency.

Unilink Outcome: The Unilink innovation effectively addressed critical Lean wastes such as waiting, unnecessary movement, and under production. By optimizing workflows, Unilink notably improved productivity and safety. Traditional methods for placing 12 beams took 60–90 minutes, involving seven workers and extensive equipment usage. The introduction of the Unilink reduced this to approximately 10–15 minutes for placing beams and decreased personnel requirements to five workers. These efficiency improvements translate directly into reduced labor involvement and increased production -- flow efficiency. Importantly, Unilink substantially improved safety by eliminating overhead hazards and minimizing tasks performed at elevated heights, further potentially contributing to other indirect cost savings associated with reduced incident rates and lower insurance premiums.

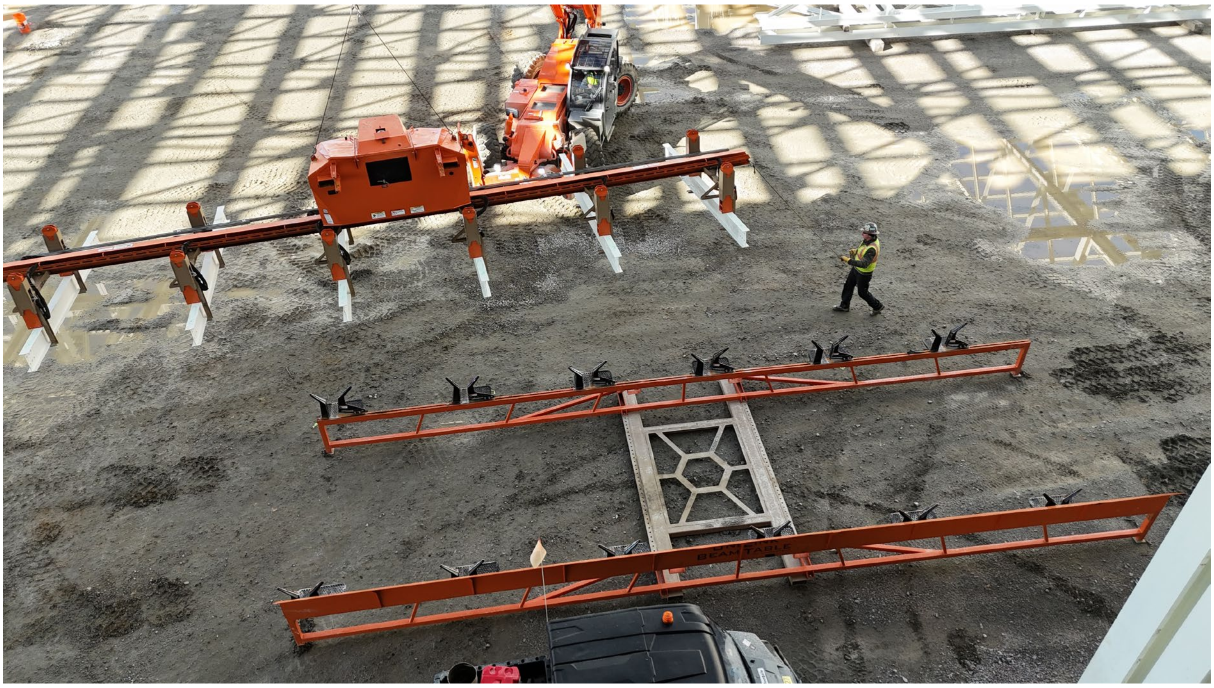

Figure 2: Unilink in Operation

Wide Swivel Carriage (WSC) Outcome: The wide swivel carriage addressed inefficiencies with material handling like extra processing of material, unnecessary movement, and excess transportation. Traditional methods required extensive resources, including a crane, aerial lift, forklift, and a four-person crew, taking approximately one hour per truss load. In contrast, the WSC attachment streamlined unloading to ten minutes, requiring fewer resources (only a forklift with two operators). This innovation led to considerable time savings, minimized equipment costs, and reduced labor expenditures. Additionally, the WSC attachment improved safety by eliminating complex crane operations, further decreasing potential costs associated with accidents and delays. Collectively, these innovations demonstrate substantial economic benefits by improving workflow efficiencies, reducing operational costs, and delivering sustainable economic value to construction projects.

Figure 3: WSC Attachment on Forklift

BZI ALIGNMENT TO 'LEANOVATION' FRAMEWORK

BZI's innovation process aligns seamlessly with the Leanovation framework by merging Lean Construction principles with strategic innovation management to address industry-specific challenges. At its foundation, BZI emphasizes a people-first approach, prioritizing the safety, well-being, empowerment, and engagement of the workforce while maintaining a secondary focus on quality and efficiency. This commitment to respect for people is evident in the collaborative development of tools like the Unilink and WSC, where leadership, engineers, and field teams work together to create effective novel solutions to jobsite constraints.

BZI's innovation process has an iterative component which further supports its alignment with the Leanovation framework. The company refines tools and equipment to address practical challenges effectively by incorporating continuous feedback from all stakeholders. BZI demonstrates agility through rapid prototyping.

LIMITATIONS AND FUTURE RESEARCH

LIMITATIONS OF THIS STUDY

This research uses a case study method to unveil BZI's innovative process. While this approach offers valuable, steel erection insights, the applicability to other specialty contractors is limited and recommended for future research. Furthermore, most of the financial and overall schedule information was restricted due to non-disclosure agreements. These factors limited the depth of analysis that the authors were able to go into. Finally, the project team having authorship on this paper presents bias throughout the writing.

FUTURE RESEARCH

Future research should expand on BZI's safety, quality, and production success with the Unilink and wide swivel carriage innovations. These innovations serve as practical examples of how a lean organization drives innovation within an entire industry. The authors recommend the following as future research opportunities:

1. Quantifying Long-Term Benefits: The Unilink and Wide Swivel Carriage merit further study to quantify lifecycle benefits such as cost savings, safety improvements, and productivity gains. Future research should focus on developing standardized metrics to measure reductions in Lean wastes.
2. Expanding Human-Centric Practices: Future research should explore how workforce involvement impacts morale, retention, and innovation adoption. Further research should explore how BZI safely integrated this work into their current workflow.
3. Replicability Across Sectors: BZI's innovation process offers potential for broader use beyond steel erection. Future research should investigate how the innovation process could be used in other trades to invent novel tools or equipment. Additionally, future research should investigate adapting BZI's innovation framework beyond steel erection, such as in concrete, identifying practical ways to transfer knowledge across sectors.

The Unilink and WSC attachment highlight BZI's Innovation process, capabilities, and willingness to tackle significant challenges in the construction sector by applying Lean Construction principles. While prioritizing the well-being of workers, safety, quality, and operational efficiency, BZI has innovated how industry constraints are could be addressed. These tools enhance safety, quality, and integrate operational efficiency with practices that place workers at the forefront. In an industry often hindered by inefficiencies and resistance to change, BZI’s methodology serves as an inspirational, flexible, and effective model. This Innovation process underscores the potential of continuous improvement and collaborative innovation to elevate industry practices, foster Lean principles, and drive sustainable advancements that benefit the people performing the work.

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