Results of a Pilot Site Study Disrupters, Enablers and Variability Impacting Construction Productivity: Key Findings from 1 Broadgate Project.

Overview

The 1 Broadgate project, a £300 million commercial office development in central London, is a flagship of British Land's Broadgate regeneration initiative. Key project parties include British Land (Client), Sir Robert McAlpine (Main Contractor), and key supply chain partners Focchi Ltd (cladding) and Morrisroe Ltd (Concrete).

At the time of the study (April 2025), the project is nearing completion, with cladding and concrete work packages completed. This case study, part of Phase 2 of the Construction Productivity Taskforce's (CPT) Pilot Sites workstream, focuses on slipform operations (two reinforced concrete cores) and cladding operations (installation of circa 2,696 unitised façade panels).

Data collection adhered to the CPT Measurement Framework, as outlined in Measuring Construction Site Productivity: A Seven-Step Framework for Success (2022), leveraging digital technologies to ensure accuracy and granularity. These included Excel-based trackers for progress records, progress analysis via Disperse technologies, time-lapse photographic records via Site-Eye technology, BIM models, and programme documentation amongst other.

Productivity metrics analysed included rates of installation, production cycle times, labour productivity (units/worker-hour) following the Cambridge Performance and Productivity Framework outlined in Measuring Construction Productivity across Projects: Multilevel Three-Dimensional Framework (2024). These methods supported detailed analysis of disrupters and variability, drawing on insights from pilot projects like Landsec's The Forge and British Land's Norton Folgate to provide actionable strategies for industry-wide productivity gains. More detailed analysis and all figures can be found in the Case Studies section.

Acknowledgements

Many thanks to the following who contributed to these case studies:

Ashan Senel Asmone – Research Associate, University of Cambridge
Danny Murguia – Senior Research Associate, University of Cambridge
Javier Lopez – Strategic Digital Programme Manager, Sir Robert McAlpine
Jas Degon – Senior Planner, Sir Robert McAlpine
Shayne Gee – Cladding Manager, Sir Robert McAlpine
Antony Blair – Slipform Project Manager, Morrisroe Ltd
Duncan White – Operations Director, Morrisroe Ltd.

Key Findings

Work Package – Concrete Operations (Specifically Slipform Activities)

Productivity Overview: The slipform operations, as outlined in Case Study: Enhancing Productivity and Efficiency in Concrete Operations, successfully completed the construction of two reinforced concrete cores between February and May 2023, finishing the projects **two weeks ahead of schedule**. The delivery team achieved and surpassed the target climb rate of 1.7 meters per day, with top performance daily climb rates (upper quartile) ranging from 1.73 to 2.70 meters for the West Core and from 2.26 to 2.70 meters for the East Core. This performance, characterized by a **factory-like approach**, maintained consistent progress with a continuous flow and minimal interruptions as depicted in *Figure 1 West Core Flowlines (Plan v Actual)* and *Figure 2 East Core Flowlines (Plan v Actual)*.

The success was achieved through **early collaboration with Morrisroe Ltd**, which enhanced the design intent by focusing on the constructability of the concrete cores and implementing a 'design for construction' approach. The introduction of **slipform technology** created a controlled environment, ensuring consistent concrete pouring volumes each day, stable progress in daily climb rates, and avoiding the intermittent cycles of traditional formwork thus enhancing productivity from the outset. This is demonstrated by the minimal variability in core height progress for the two slipform cores – as per *Figure 4 Core Height Progress Variability* - with median progress heights of approximately 1.39 meters per day for the West Core and approximately 1.85 meters per day for the East Core.

Significant enhancements in productivity were also accomplished through the application of **innovative engineering solutions** aimed at optimizing concrete placement activities which resulted in a reduction of cycle times from the planned three days to two days for 65% of the recorded period, as demonstrated in *Figure 7 West Core Cycle Times (Plan v Actual)* and *Figure 8 East Core Cycle Times (Plan v Actual)*. Additional strategic measures involve employing **digital technologies to monitor deliveries**, thereby guaranteeing accurate delivery timing with consistent placement times (median 55 minutes, range 40–120 minutes).

Productivity Disrupters

- **Use of Traditional Systems:** As described in Case Study: Enhancing Productivity and Efficiency in Concrete Operations, initial consideration of traditional formwork methods risked slower progress and longer cycle times, potentially limiting climb rates to 0.7-1.2 metres/day. The adoption of slipform construction, introduced through **early partnership with Morrisroe Ltd**, supported a factory-like system yielding more consistent vertical progress with median climb rates of 1.39 m/day (West Core) and 1.85 m/day (East Core), surpassing targets.
- **Task Sequencing:** Initially, the project team planned a three-day floor cycle based on the installation of embedment plates at a specific height per level during the cycle. By **restructuring the slipform construction sequence**—allocating more concrete pouring to the first day and assigning embedment work to a dedicated timeframe on the second day—the construction sequence was optimized. The floor cycle duration was shortened to two days, leading to an increase in production rates that exceeded the planned 363 m²/day for West Core and 245 m²/day for East Core, with third quartile performance reaching 510 m²/day and 375 m²/day, respectively. This intervention illustrates how minor adjustments in task sequencing can significantly enhance output.
- **Delivery Delays:** Concrete lorries sometimes arrived late or out of sequence, affecting pour start times and shift durations. In the worst-case scenario, placement took 112 minutes, with 20% of the time due to waiting for concrete. This delay decreased the number of pours achievable per shift and caused inefficiencies in labour readiness and line preparation. The **use of digital technologies to track deliveries** such as the Cemex Go App facilitated precise delivery timing, enabled proactive planning and immediate response to lorry arrival, thereby improving pour timings and enhancing productivity.
- **Quality Control:** Despite maintaining an average of nine concrete loads per day, the project experienced intermittent delays linked to variations in concrete curing times. Upon investigation, Morrisroe identified that a change in cement supplier—from Rugby to Tilbury cement—had significantly affected the hydration profile of the concrete. This led to slower setting times, disrupting the planned progression of the slipform operation and reducing the reliability of the construction cycle. In response, the site team focused on **effective plant-site coordination**, ensuring direct communication with the supplier's team, Cemex, at the plant to secure the specified concrete mix and reserve silo capacity to prevent further variability. This example demonstrates how uncoordinated supply chain adjustments—particularly in material specifications—can impact productivity.

Production Variability

- **Floor Cycle Time:** The majority of core floor cycles were maintained within 2–3 days, with the West Core showing a median of 3 days and the East Core a median of 2 days as demonstrated in *Figure 7 West Core Cycle Times (Plan v Actual)* and *Figure 8 East Core Cycle Times (Plan v Actual)*. This consistency -due to the adjustment of the slipform construction sequence- was key to exceeding the planned programme were associated with higher production rates (>363 m²/day).

- **Height Progression:** The West Core had a median daily climb rate of 1.39 m/day - with a interquartile range (0.79–1.73 m/day)-, while the East Core achieved 1.85 m/day, with a narrower interquartile range (1.27–2.26 m/day), indicating greater consistency and reduced disruption (see *Figure 4 Core Height Progress Variability*). High variability of the west core is attributed to issues with the concrete mix and delays in deliveries affecting the February to March 2023 period.

- **Placement Time:** Daily pour durations averaged 55 minutes, with week-over-week variations limited to 20 minutes, and most within the benchmark window of 45–60 minutes. While most pours met the benchmark, outliers (≥80 min) revealed bottlenecks due to late deliveries or inadequate mix consistency.

Works Package – Cladding Operations

Productivity Overview: The cladding operations, as detailed in Case Study: Enhancing Productivity and Efficiency in Cladding Operations, involved installing 2,696 unitised façade panels from March to July 2024, completing construction works **on time.** The delivery team achieved an average installation rate of 17 panels/day, surpassing UK industry benchmarks of 10–15 panels/day (CPA, 2021) with peak outputs reached 38 panels installed per day as illustrated in *Figure 17 Daily Installation of Panels and Variability*. This performance was driven by a **modern logistics-led approach**, maintained consistent progress with a continuous flow and minimal interruptions as depicted in *Figure 18 Flowlines for cladding installation*.

The success was attributed to the implementation of advanced logistics solutions from levels 3-12 to **decouple façade panels installation from their vertical distribution**, thereby decreasing reliance on tower cranes and enabling simultaneous work across up to three floors. The logistics solution included establishing a **floor-by-floor façade assembly line**, utilizing a large hoist for vertical distribution, tables for horizontal distribution within each floor, and a spider crane from two floors above to lift the cladding unit to its installation point.

This approach significantly increased façade installation productivity by enabling consistent, high-volume delivery. As shown in *Figure 21 Cladding Production Rate Variability based on Logistics Scenarios*, the implementation of the logistic solution implemented for Levels 3-12 achieved a **140% improvement in median output** compared to the crane-dependent strategies, which recorded median installation rates of just 9-10 units/day. These results reinforce the value of logistics strategies that decouple vertical distribution from centralised lifting constraints, supporting repeatable, scalable, and resilient façade operations.

Productivity Disrupters

- **Early-Stage Logistics Planning**: In tall building construction, logistics for cladding operations is frequently treated as a downstream operational task rather than a strategic design input. At 1 Broadgate, the project team reversed this paradigm by integrating logistics considerations directly into the design process. The project team developed **specific logistical solutions to optimise the delivery**, designed to support the building-kit-of-parts system for prefabricated cladding panels. This strategy allowed the team to tailor delivery methods to the unique requirements of each cladding zone/level, addressing factors like access points, building elevations, and specific installation schedules. Depicted in *Figure 19 Logistics Solutions: Stillage Unloading and Vertical Distribution Strategy,* the approach was structured around multiple logistics cases each carefully calibrated to optimize site-specific conditions. As a result of this integrated planning, the project achieved a median installation rate of 17 units/day, with best performance (top quartile) between 23 and 38 units/day, exceeding conventional UK benchmarks for high-rise unitised cladding.
- **Tower Crane Dependency**: Façade installation in high-rise buildings has traditionally relied on tower cranes for vertical distribution, but this dependency imposes critical limitations on productivity. At 1 Broadgate, the application of a **decentralised logistics model for levels 3-12** that utilised the Mammoth Hoist for delivery to floor-level staging areas, launching tables for unit positioning, and spider cranes for final installation—completely bypassing the tower crane. This configuration enabled up to three active installation floors simultaneously, with floor cycles reduced to 3–4 weeks and installation rates frequently reaching 26-38 units/day. This data underscores that tower crane dependency is not only a logistical bottleneck but a structural constraint on productivity that must be overcome through application of advanced logistics solutions to maximise construction efficiency.
- **Weather-related delays:** Wind sensitivity remains a major disruptor to high-rise cladding productivity, particularly where tower cranes are used, as operations are typically suspended above 38 km/h wind speeds. At 1 Broadgate, installation progress was notably constrained on levels 1, 2, and 13, with eight recorded instances of reduced output due to wind speeds exceeding 40 km/h—conditions under which daily installation rarely surpassed 15 units. In contrast, levels 3 to 12 benefited from a **weather-resilient logistics strategy** that incorporated Mammoth Hoists, floor-level stillages, and spider cranes. This approach effectively mitigated the impact of adverse weather, allowing installation to continue with minimal disruption. As shown in *Figure 23 Correlation Between Output and Weather Disruption*, this strategy consistently maintained 25–35 units/day even during elevated wind periods. This continuity was essential in achieving accelerated floor cycles (as low as 3 weeks) and maintaining high labour productivity rates of 0.06–0.12 units/worker-hour.

Production Variability

- **Labour Productivity:** Labour productivity was a critical determinant of installation performance across logistics scenarios, with notable fluctuations between strategies. Strategy 2 (Levels 3–12), which operated as a decentralised, floor-based system achieved the highest productivity values, with best performance (top quartile) between **0.06 and 0.10 units per worker-hour**. In contrast, Strategy 1 (levels 1 and 2)—more reliant on tower cranes and manual handling—were generally confined to **0.05–0.06 units per worker-hour**, with occasional drops below the 0.03 threshold. These variances highlight the benefits of repetitive task cycles, reduced wait times, and decentralised workflows in improving crew efficiency.

- **Daily Installation Output:** There are distinct patterns depending on the vertical logistics strategy implemented. Strategy 2 (Levels 3–12) produced the **highest variability range (18–38 units/day)**, but also the most robust peak performance, surpassing both internal and external benchmarks. Strategies 1 and 3 (levels 1,2 and 13) delivered far narrower and lower output ranges of **8–15 units/day**, with median values at 9 and 10 units/day respectively. The greater variance under Strategy 2 is attributable to its capacity for simultaneous multi-floor operations and scalable workflows. This output profile confirms that scalable logistics systems unlock productivity potential but introduce variability that must be managed.

- **Floor Cycle times:** Under Strategy 2 (Levels 3–12), the cycle from **Level 4 to Level 5 was completed in just three weeks**, while **Level 3 to Level 4 was completed in five weeks**, both executed concurrently. This compressed timeline reflects the impact of concurrent floor operation and structured sequencing. In contrast, Strategy 1 and 3 (levels 1,2 and 13) required **five to six weeks per floor**, a result of tower crane dependency, single-stream workflow, and restricted access. Overall, Strategy 2 yielded **up to 40% shorter cycle times**, directly linked to floor-level autonomy and vertical area utilisation.

Recommendations and Next Steps

Embed Early Supply Chain Collaboration in Design Phases

> "Early engagement with manufacturers and specialist contractors improves the efficiency of the design and the design process through a better understanding of manufacturing capabilities, logistics constraints and on-site buildability" (Trust and Productivity: Private sector construction playbook (2022), p. 14).

Action: Formalize supply chain engagement during pre-construction to co-develop strategies that look at improving the design through better understanding of buildability, logistics, delivery and manufacturing.

Early engagement with supply chain partners, as demonstrated by Morrisroe Ltd's slipform design and Focchi Ltd's cladding logistics planning, is critical for optimizing buildability and aligning construction methods with project timelines. For concrete operations, Morrisroe's input 9 months prior to construction enabled a slipform approach, resulting climb rates of **1.73–1.85 m/day** and a **2-week schedule gain** (*Figure 4 Core Height Progress Variability*). Similarly, cladding operations benefited from early logistics planning integration, resulting in a median installation rate of **17 panels/day**, surpassing benchmarks of 10–15 panels/day (*Figure 17 Daily Installation of Panels and Variability*).

Adopt Logistics Models to Enable Floor-level Autonomy and Mitigate Weather-related Delays

Decentralized logistics, as demonstrated by the use of Mammoth Hoisting and spider crane system in cladding's Scenario 2 (Levels 3-12), decoupled installation from tower crane dependency, enabling concurrent work across multiple floors and help achieving **peak outputs of 38 installed cladding panels a day** (*Figure 21 Cladding Production Rate Variability based on Logistics Scenarios*) and mitigate weather-related delays, maintaining **25–35 panels/day** during winds up to >35 km/h (*Figure 23 - Correlation Between Output and Weather Disruption*). **Action:** Prioritize logistics solutions that enable concurrent work across multiple fronts and sheltered operations, reducing reliance on centralized equipment and external conditions.

> "Teams will need to rethink the logistics solutions employed on construction projects to meet the new business models driven by highly systemised solutions and disruptive technologies" (Trust and Productivity: Private sector construction playbook (2022), p. 33).

Leverage Digital Technologies Tools for Deliveries and Installation Traceability: The adoption of digital workflows, such as concrete delivery tracking using Cemex's application *(Figure 14 Cemex Go App Example*) and asset tagging for cladding panel (*Figure 25 - Storage and Shipping Process*), **improve predictability and minimized variability for on-site operations**. The Cemex app stabilized concrete placement times, while QR-code tracking ensured accurate panel sequencing, reducing errors and supporting real-time progress monitoring (*Figure 26 - Construction Records including FIN/CE Codes*). **Action**: Deploy integrated digital platforms for real-time tracking of materials, deliveries, and progress, enhancing coordination and quality assurance.

> "Projects should embed digital information flows across the whole life of the asset, which can be enabled and supported by sensors, intelligent machines, mobile devices and new software applications that automate design and construction processes." (Trust and Productivity: Private sector construction playbook (2022), p. 14).

Optimize Task Sequencing to Streamline Workflows: Strategic task sequencing significantly enhanced productivity in both work packages. For concrete operations, resequencing embedment plate installation to allocate more concrete pouring on day 1 and dedicate day 2 to embedment work reduced floor cycle times from 3 to 2 days, **boosting production rates to >363 m²/day** (*Figure 11 Cycle Time v Production Rate*). In cladding operations, Scenario 2's concurrent multi-floor installation sequence enabled parallel workflows, compressing floor cycle times to as low as 3 weeks for Levels 3–4, compared to 5–6 weeks in crane-dependent scenarios (*Figure 18 Flowlines for cladding installation*). **Action:** Conduct detailed workflow planning to prioritize parallel task execution and minimize sequential dependencies, ensuring efficient cycle times and resource utilization.

> "Continuous measurement and capturing of success and failure, together with feedback captured at both project and wider level, will help safeguard the delivery" (Trust and Productivity: Private sector construction playbook (2022), p. 64).

References

- Be the Business. (2022). *Measuring Construction Productivity: The Construction Productivity Taskforce Report*. Available at: https://bethebusiness.com/files/construction-taskforce/btb_measuring_construction_productivity_25august.pdf.
- Be the Business. (2022). *Trust and Productivity: The private sector construction playbook*. Available at: https://bethebusiness.com/files/research-reports/5195_construction_brochure_singlepgs.pdf.
- Construction Leadership Council. (2019). *Productivity in Construction: A Review of Industry Benchmarks and Performance Metrics*. [Report]. Construction Leadership Council, UK.
- Case Study: Enhancing Productivity and Efficiency in Cladding Operations – Results of a Pilot Site Study. Construction Productivity Taskforce, 2024.
- Case Study: Enhancing Productivity and Efficiency in Concrete Operations – Results of a Pilot Site Study. Construction Productivity Taskforce, 2024.
- Murguia, D., Rathnayake, A., Jansen van Vuuren, T., & Middleton, C. (2024). Measuring Construction Productivity across Projects: Multilevel Three-Dimensional Framework. Journal of Construction Engineering and Management, 150(11), 04024151.

Case Studies

The following case studies describe the productivity measurement studies and results in more detail, as follows:

- **Case Study No 1:** Enhancing Productivity and Efficiency in Concrete Operations – Results of a Pilot Site Study
- **Case Study No 2:** Enhancing Productivity and Efficiency in Cladding Operations – Results of a Pilot Site Study

Case Studies

Case Study No 1: Enhancing Productivity and Efficiency in Concrete Operations – Results of a Pilot Site Study

Acknowledgements

Ashan Senel Asmone – Research Associate, University of Cambridge
Antony Blair – Slipform Project Manager, Morrisroe Ltd
Danny Murguia – Senior Research Associate, University of Cambridge
Duncan White – Operations Director, Morrisroe Ltd
Javier Lopez – Strategic Digital Programme Manager, Sir Robert McAlpine
Jas Degon – Senior Planner, Sir Robert McAlpine.

Overview

The 1 Broadgate project represents a major private-sector commercial office development in central London, with an estimated value of approximately £300 million. During its construction phase, the site was examined to evaluate construction productivity in standard projects. The assessment aimed to identify the fundamental causes of productivity disruptions and enhancements, in alignment with Phase 2 of The Construction Productivity Taskforce's Pilot Sites study workstream.

This case study provides an in-depth analysis of slipform operations for the Broadgate project which comprises the construction of two slipform cores by Morrisroe Ltd, aiming to improve productivity in the construction industry through innovative techniques and collaboration. It also outlines the challenges faced, the solutions implemented, and the overall outcomes of the project.

The measurement and analysis of the collected data focus on productivity metrics during the construction of the two slipform cores from February 2023 to May 2023, such as installation rates, cycle times, and delivery time, according to the framework established in Phase 1—Measuring Construction Site Productivity: A Seven-Step Framework for Success (2022) and outlined in Measuring Construction Productivity across Projects: Multilevel Three-Dimensional Framework (2024).

Background

Despite early challenges, strategic approaches led to the completion of two slipform cores two weeks ahead of schedule. At the beginning, the delivery team set goals to establish a consistent rate of climb of 1.7 meters per day to ensure timely completion of the two slipform cores. The delivery team achieved the target climb rate of 1.7 meters and exceeded it, with daily climb rates surpassing 1.73 meters for the West Core for 25% of the recorded time and 1.85 meters for the East Core for 50% of the recorded time.

This study investigates the factors that contributed to this success and details how the delivery team efficiently implemented strategies to enhance productivity while mitigating disruptions. The delivery team's strategies included conducting early-stage productivity and buildability reviews, applying innovative solutions, implementing tactical measures, and utilizing digital technologies to maintain the pace of construction required.

Early Engagement with Supply Chain Partners to Maximise Construction Efficiency.

Partnering with Morrisroe Ltd during the early phases of the project provided design and buildability insights, which contributed to an efficient construction process. Morrisroe Ltd clarified the design intent by addressing constructability considerations 9 Months before works commenced on site, ensuring a 'design for construction/delivery' approach that aligns with the project programme constraints.

Morrisroe Ltd Construction Engineering Design team conducted an analysis of the core stability for both reinforced concrete cores, originally designed to be built as traditional formwork construction. They provided guidance on adopting slipform construction as a more efficient method, which relies on temporary horizontal bracing to stabilize the core during the construction process. This enhancement allowed the formwork to move vertically while being supported by the core of the structure, thus facilitating a faster construction process.

By assessing the construction methods early in the process, the site team determined that using slipform technology would provide the most controlled factory-like environment. This method enabled consistent concrete pouring volumes per day, resulting in steady progress once work commenced on site. Unlike traditional formwork construction, which requires waiting for curing before moving to the next section, this method prevents delays and operates as a continuous process rather than batch production that follows a start-stop cycle for each core wall. The flowline charts for both west and east core construction (See *Figure 1 West Core Flowlines* and *Figure 2 East Core Flowlines (Plan v Actual)*) depict this factory-like system with a continuous flow with minimal interruptions evidencing the completion of two slipform cores two weeks ahead of schedule.

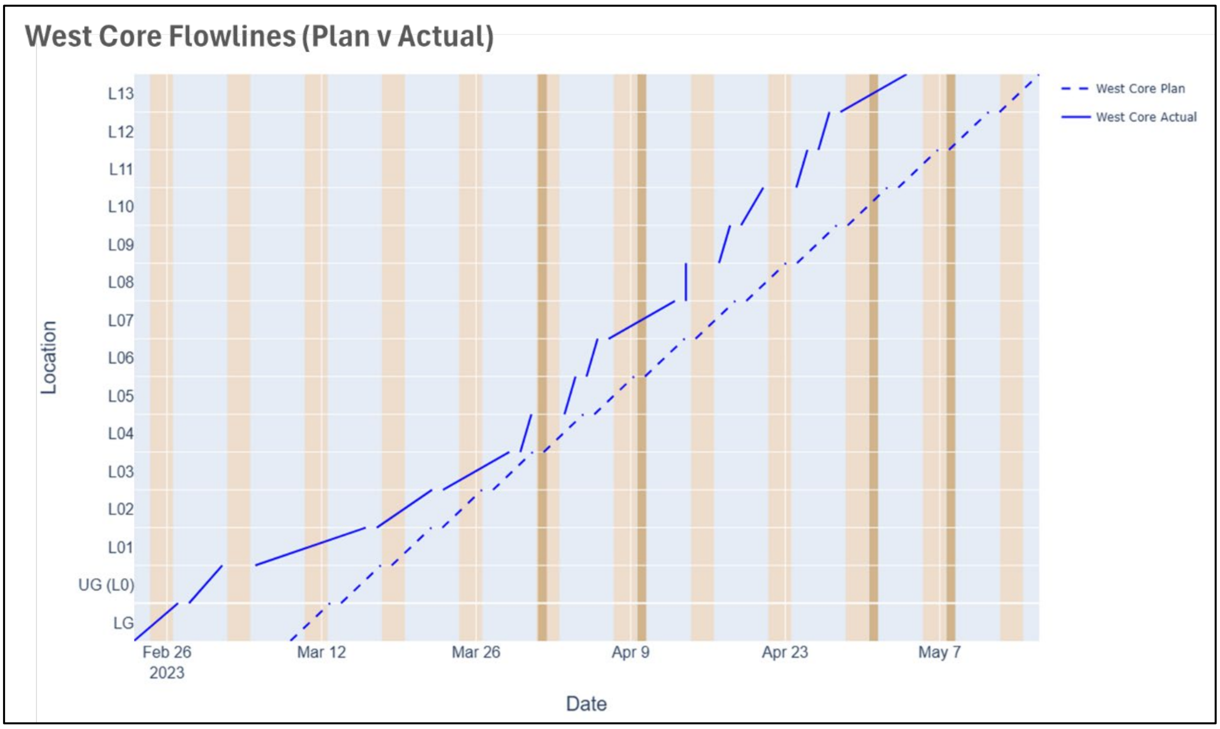


Figure 1 West Core Flowlines (Plan v Actual)

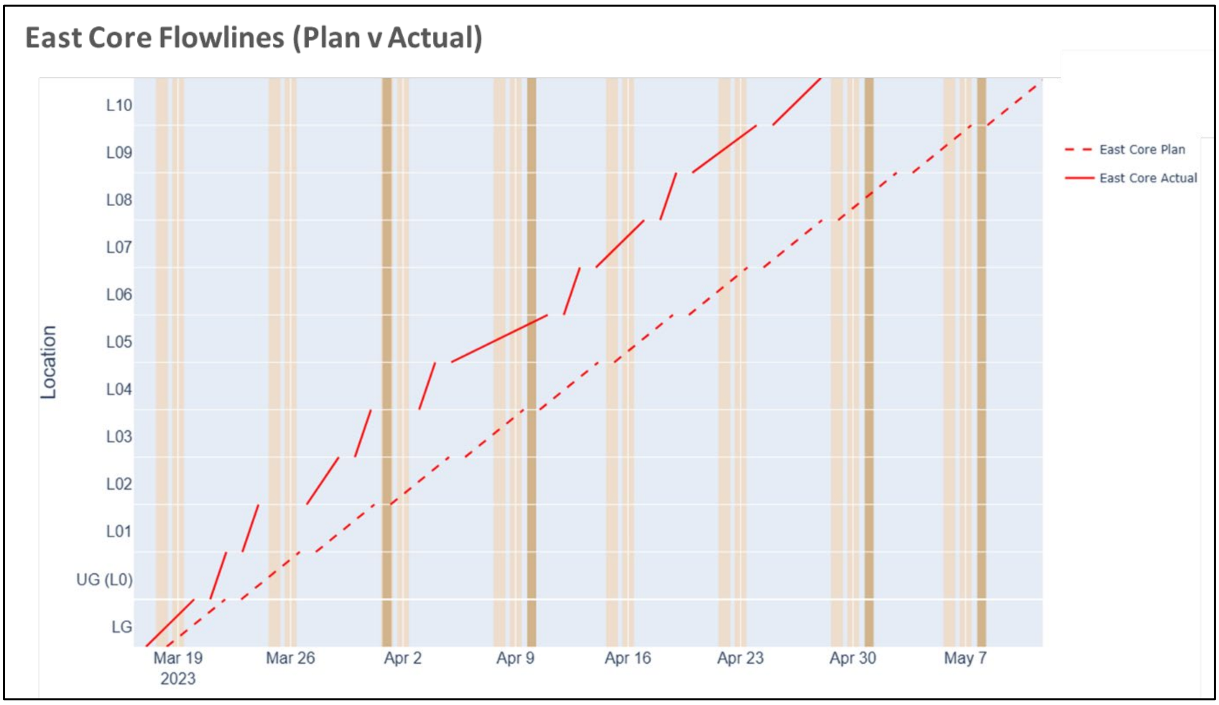


Figure 2 East Core Flowlines (Plan v Actual)

The factory-like system ensured a steady flow with minimal interruptions, reducing output variability. Analysing progress records, including visual documentation and core height measurements (see *Figure 3 Progress Records*), showed a consistent construction rate of 3.9 meters every two days from level 4 for West core and from level 1 for East Core.

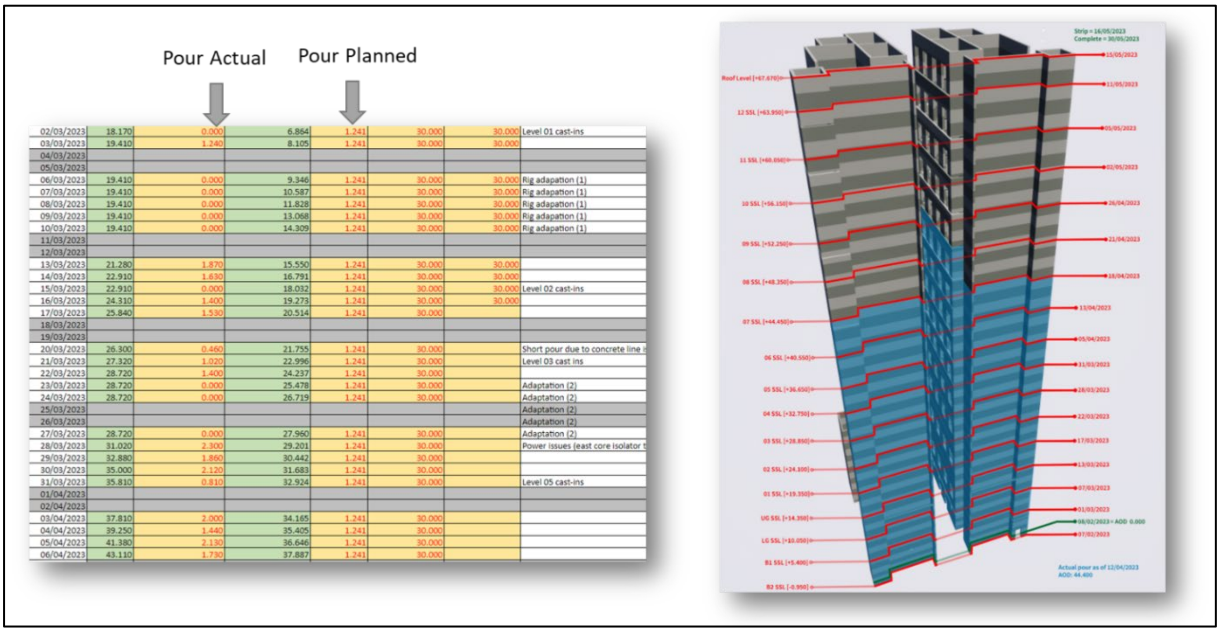


Figure 3 Progress Records

Further data analysis of these progress records demonstrated minimum variability in core height progress for the two slipform cores (see *Figure 4 Core Height Progress Variability*). The West Core, with a median progress height of approximately 1.39 meters per day, a lower quartile of 0.79 meters, and an upper quartile of 1.73 meters, indicated moderate variability while the East Core progress, showed a higher median progress height of approximately 1.85 meters per day, with a lower quartile of 1.27 meters and an upper quartile of 2.26 meters, suggesting greater consistency at a higher rate. Both boxplots showcase a narrower interquartile range, implying stable progress in daily climb rates.

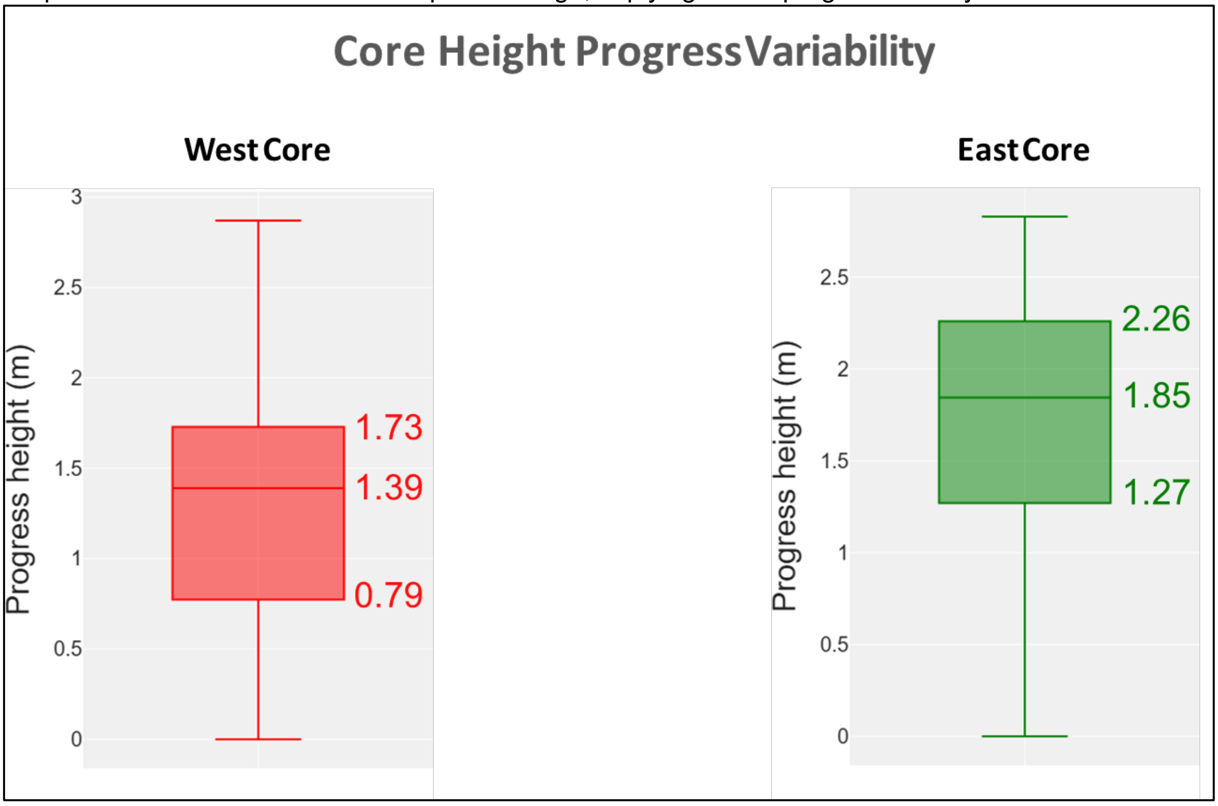


Figure 4 Core Height Progress Variability

As noted in the Private Sector Construction Playbook "Early engagement with manufacturers and specialist contractors improves the efficiency of the design and the design process through a better understanding of manufacturing capabilities, logistics constraints and on-site buildability" (Trust and Productivity: Private sector construction playbook (2022), p. 14). Engaging Morrisroe Ltd Engineering team from the outset facilitated the formulation of a plan to employ construction methods that surpass traditional approaches in speed and efficiency, thereby ensuring consistent productivity. The early inclusion of the supply chain enabled the project to utilize more efficient construction techniques, which contributed to maintaining the project timeline.

Advanced Engineering Techniques for Boosting Production Efficiency.

Initially, the project delivery team planned a 3-day floor cycle based on the installation of embedment plates at a certain height per level. As welding core embedment plates is the first task in the steelwork trade cycle, it is essential for this activity to adhere strictly to the schedule, given its critical role in subsequent placement activities.

An operational improvement decision was later made to develop a more efficient method for installing embedment plates. Installing these plates in a quicker timeline improves installation efficiency. This resulted in pouring more layers of concrete on day 1 of the cycle and conducting short concreting on the morning of day 2, then stopping concrete for embed plate installations in the afternoon, the site team maintained an efficient workflow. As a result, disruptions were minimized, and the project benefitted from a floor cycle from a 3-day floor cycle to a 2-day cycle as captured in *Figure 5 Embedment plates technical solution.*

Figure 5 Embedment plates technical solution

This engineering solution led to a more continuous workflow, enabling more concrete placement activities within a day. *Figure 6 Concrete Operations Improvement* compares the planned and improved concrete operation scenarios, showing the increase in concrete loads per day because of the reduction of the floor cycle from 3 days to 2 days.

Planned Concrete Operations vs Improved Concrete Operations

1 Broadgate Planned concrete operations morrisroe

Example L1 to L2				Layer thickness	Accumulative rise
Day 1	Load 1	08H00		400	
	Load 2	10H00		400	800
	Load 3	11H30		300	1100
	Load 4	13H00		300	1400
	Load 5	14H30		300	**1700**
Day 2	Load 1	08H00		400	2100
	Load 2	10H00		400	2500
	Load 3	11H30		400	2900
	Load 4	13H00		300	3200
	Load 5	14H30		300	**3500**
Day 3	Load 1	08H00		400	**3900**
		09H00		Embedment plate install	
		10H00		Embedment plate install	
		11H00		Embedment plate install	
		12H00		Embedment plate install	
		13H00		Embedment plate install	
		14H00		Embedment plate install	

1 Broadgate Improved concrete operations

Example L1 to L2		Improved concrete mix setting and placing times			
				Layer thickness	Accumulative rise
Day 1	Load 1	08H00		300	
	Load 2	09H00		300	600
	Load 3	09H45		300	900
	Load 4	10H30		300	1200
	Load 5	11H15		300	1500
	Load 6	12H00		300	1800
	Load 7	12H45		300	2100
	Load 8	13H30		300	2400
	Load 9	14H15		300	**2700**
Day 2	Load 1	08H00		300	3000
	Load 2	09H00		300	3300
	Load 3	09H45		300	3600
	Load 4	10H30		300	**3900**
		11H30		Embedment plate install	
		12H30		Embedment plate install	
		13H30		Embedment plate install	
		14H30		Embedment plate install	
		15H30		Embedment plate install	
		16H30		Embedment plate install	

Figure 6 Concrete Operations Improvement

Subsequently the site team monitored the timing of each cycle continuously to maintain the 2-day cycle during the execution of both cores. As shown in *Figure 7 West Core Cycle Times (Plan v Actual) and Figure 8 East Core Cycle Times (Plan v Actual)*, floor cycle times were recorded to be within the 2 to 3 days range for more than 65% of the recorded time. Records for both cores also exhibit minimal variability, with a median of 3 days for the West Core and 2 days for the East Core. This indicates consistency and stability in the floor cycle times, thereby affirming the efficacy of the technical solution implemented.

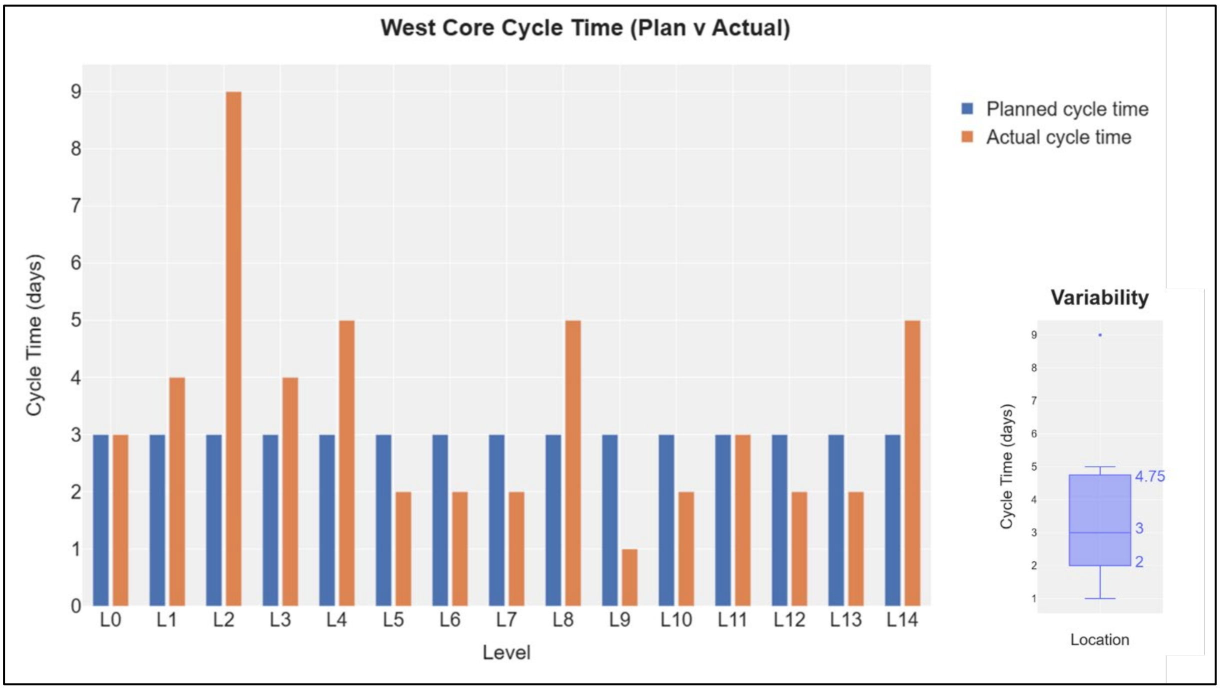


Figure 7 West Core Cycle Times (Plan v Actual)

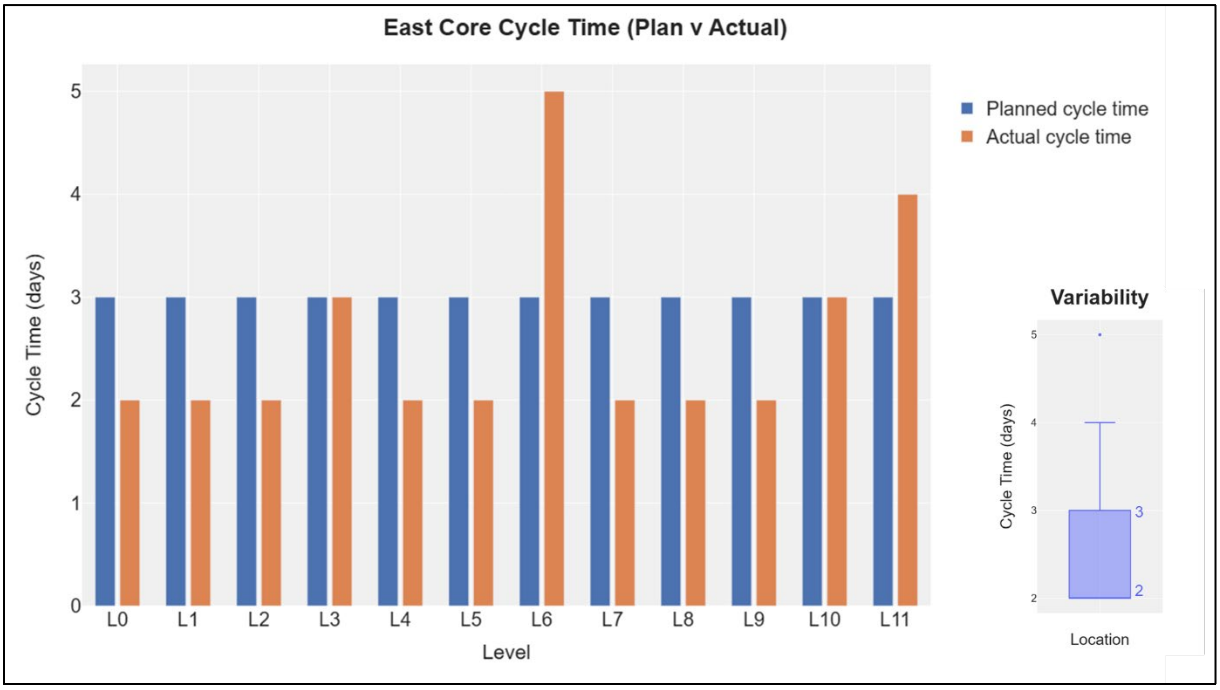


Figure 8 East Core Cycle Times (Plan v Actual)

The establishment of factory-like conditions, which ensured a continuous flow, coupled with the application of innovative engineering solutions, significantly improved production levels during the construction of the two slipform cores. As shown in *Figure 9 West Core Production Rates (Plan v Actual)* and *Figure 10 East Core Production Rates (Plan v Actual)*, the actual production rates met or exceeded the planned rates in 9 out of 15 levels for West Core and 10 out of 12 levels for East Core contributing to completion of the two slipform cores two weeks ahead of schedule.

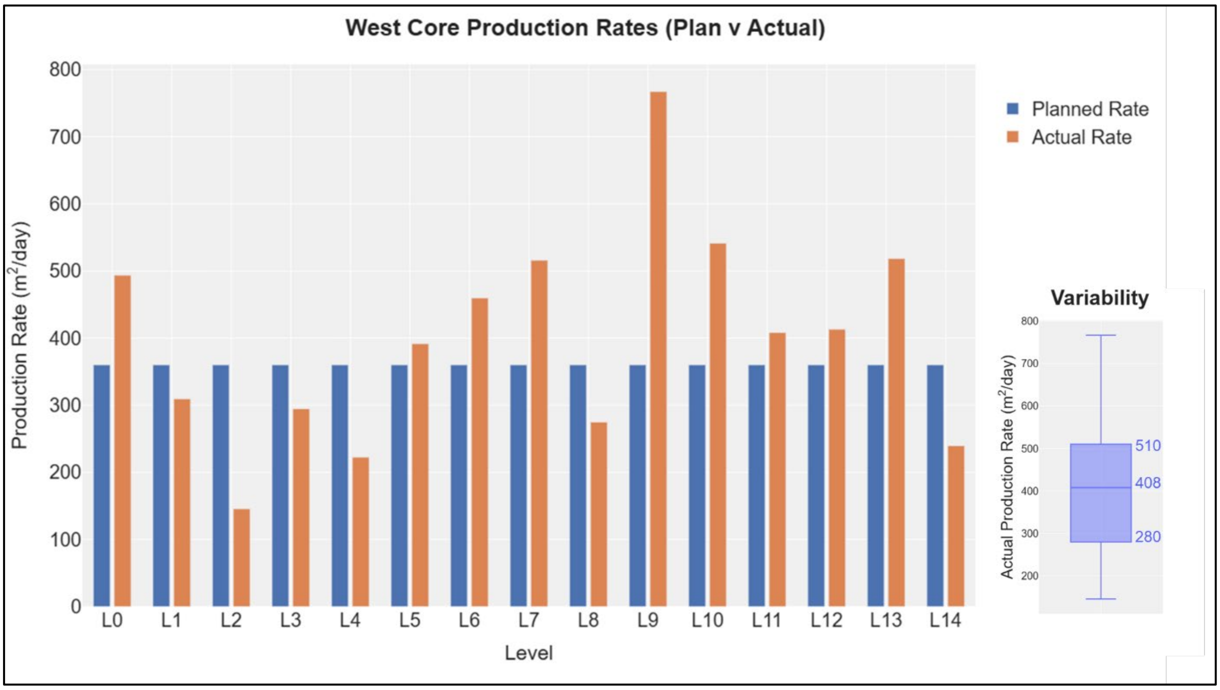


Figure 9 West Core Production Rates (Plan v Actual)

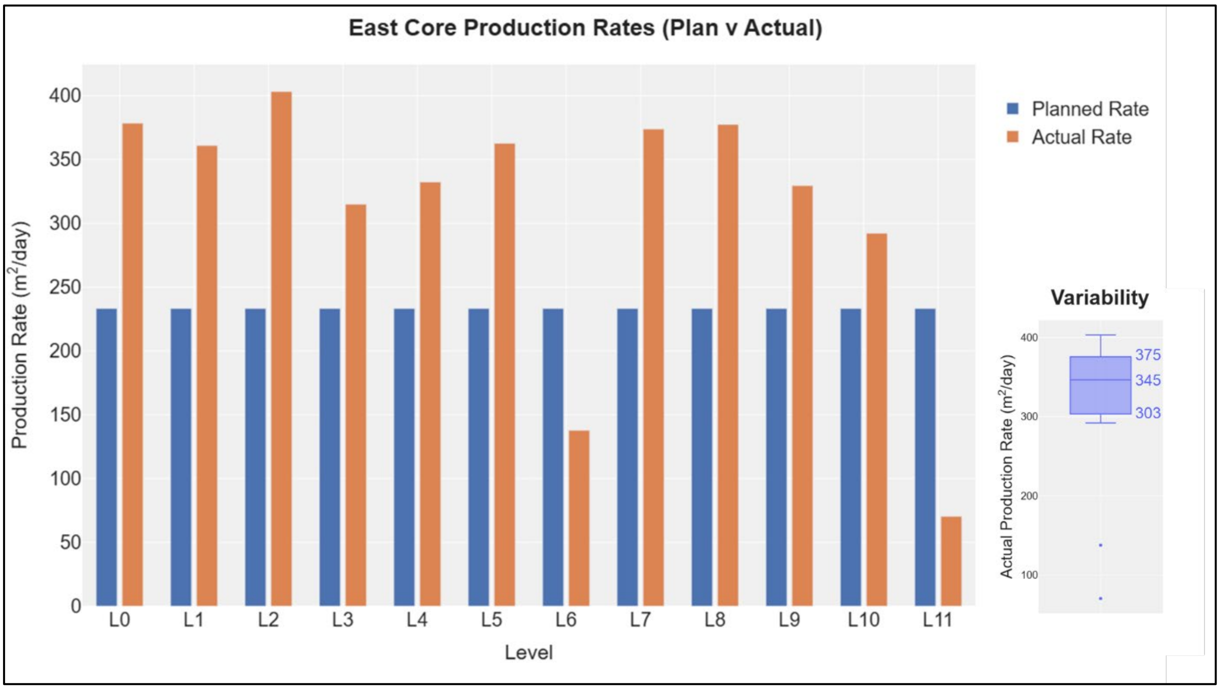


Figure 10 East Core Production Rates (Plan v Actual)

As expected with the observed modification, the reduction in cycle time allowed for an increase in concrete placement activities per day, thereby directly enhancing production rates. Further study of this correlation, as shown in *Figure 11 Production Rate v Cycle Time*, indicates that shorter cycle times (closer to 2-3 days) are associated with higher production rates, whereas longer cycle times (beyond 4-5 days) correlate with lower production rates. Optimal performance occurs in the lower cycle time range (around 2-3 days) with a production rate above 363 m²/day. Data points in this region suggest **efficient productivity**, meaning the project progresses faster while maintaining a high output.

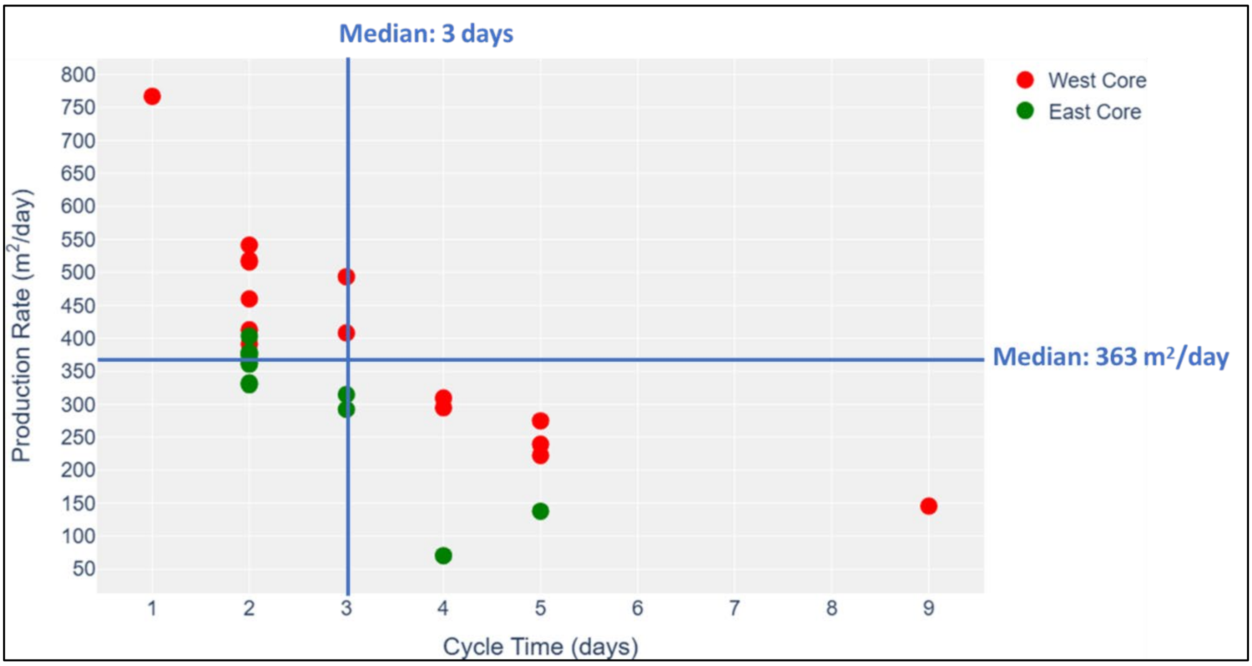


Figure 11 Production Rate v Cycle Time

In conclusion, the implementation of innovative engineering solutions, such as the installation of higher embedment plates and the reduction of cycle times from three to two days, significantly enhanced the efficiency and speed of concrete operations. This strategy showcased the delivery team's ability to design solutions that result in operational improvements as suggested in the Private Sector Construction Playbook *"Teams will need to rethink the logistics solutions employed on construction projects to meet the new business models driven by highly systemised solutions and disruptive technologies"* (Trust and Productivity: Private sector construction playbook (2022), 2022, p. 33). This resulted in actual production rates surpassing the planned targets. Consequently, a standard for production rates above 363 m²/day was established for shorter cycle times (approximately 2-3 days).

Strategies to Identify and Address Productivity Disrupters.

During the construction of two slipform cores by Morrisroe Ltd, the site team meticulously monitored the activities and durations of each shift. This included tracking delivery times, concrete placement times, and concrete curing times. The site team aimed to ensure a seamless process flow on a shift-by-shift basis by promptly addressing any potential disruptions and maintaining operational efficiency.

With the daily load count remaining relatively consistent at an average of 9 loads per day, there were instances of significant variability in curing time. Morrisroe monitored the concrete slump both at their supplier's plant and on site and observed a significant reduction in concrete slump during transportation, indicating a slow hydration process. Morrisroe contacted the supplier to investigate the cause of the change. The supplier had transitioned from using Rugby cement to Tilbury cement, resulting in a difference in setting times that would affect the progress of the slipform operation. Consequently, supply was temporarily switched to another plant with available stock of Rugby cement, while a silo at the local plant was reserved exclusively for Rugby cement for the remainder of the project.

As emphasized in the Private Sector Construction Playbook, "Continuous measurement and capturing of success and failure, together with feedback captured at both project and wider level, will help safeguard the delivery… " (Trust and Productivity: Private sector construction playbook (2022), p. 64). Without effective monitoring of cycle times and other metrics such as curing times, the change in cement composition would have remained undetected, potentially causing delays. The delivery team noted fluctuations in curing times, which led to additional hours worked on site, and they adapted accordingly.

After stabilising curing times, the site team continued to monitor each concrete pour activity and its duration to ensure consistency in placement activities on site. Consistency was maintained through continuous observation, with the site team reporting an average placement time of 55 minutes ranging from 40 to 120 minutes. This was within the established benchmark range of 45 to 60 minutes for placement durations, set at the start of concrete operations. Observations over a week—see *Figure 12 Placing Time Variation Over Time*—showed consistent placing times with a weekly variation of 20 minutes. However, there was potential for improvement in scenarios where placement times exceed 80 minutes, with a peak of 120 minutes in the worst-case scenario.

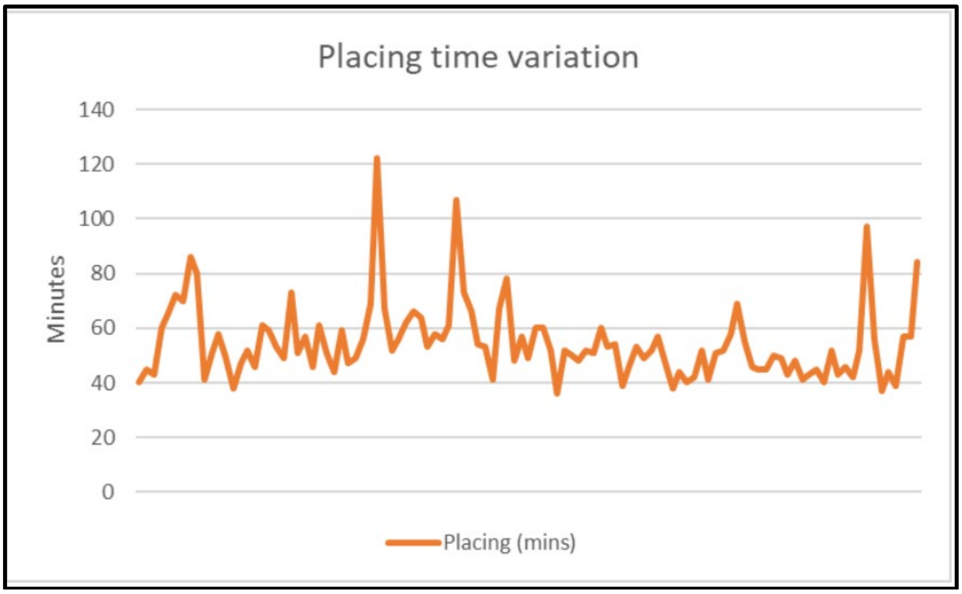


Figure 12 Placing Time Variation Over Time

An analysis of the worst-case scenario, as illustrated in *Figure 13 Placing time analysis (Worst-case scenario)*, revealed that the placing process took a total of 112 minutes. Of this duration, 20% was attributed to waiting for concrete deliveries. This prompted the site team to explore various solutions aimed at reducing disruptions and addressing the identified inefficiencies to ensure regular intervals between pours. Initially, there were challenges in receiving concrete at the preferred times; however, the team worked on implementing different solutions to reduce disruptions and address the identified wasted time.

Figure 13 Placing time analysis (Worst-case scenario)

Firstly, the site team concentrated on effective plant-site coordination, ensuring direct communication between the placing team and concrete batcher on site, as well as the supplier's team, Cemex, at the plant. The management team resolved to assign an individual at the batching plant to check the slump, ensuring it was of the correct consistency upon arrival at the site. This proactive approach assisted in mitigating delays and maintaining a consistent workflow without compromising delivery intervals.

Secondly, the site team focused on enhancing the predictability of deliveries by adopting a digital solution provided by Morrisroe Ltd' supplier, Cemex, to track concrete deliveries – Refer to *Figure 14 Cemex Go App Example*-. There were instances where, despite booking the first concrete delivery for 8:00 AM, delays at the beginning of the shift led to reduced output. The project delivery team addressed this issue by utilizing the Cemex app, which provided real-time updates on the status of deliveries. This proactive approach allowed the team to prepare in advance, thereby significantly improving the timing and coordination of concrete deliveries.

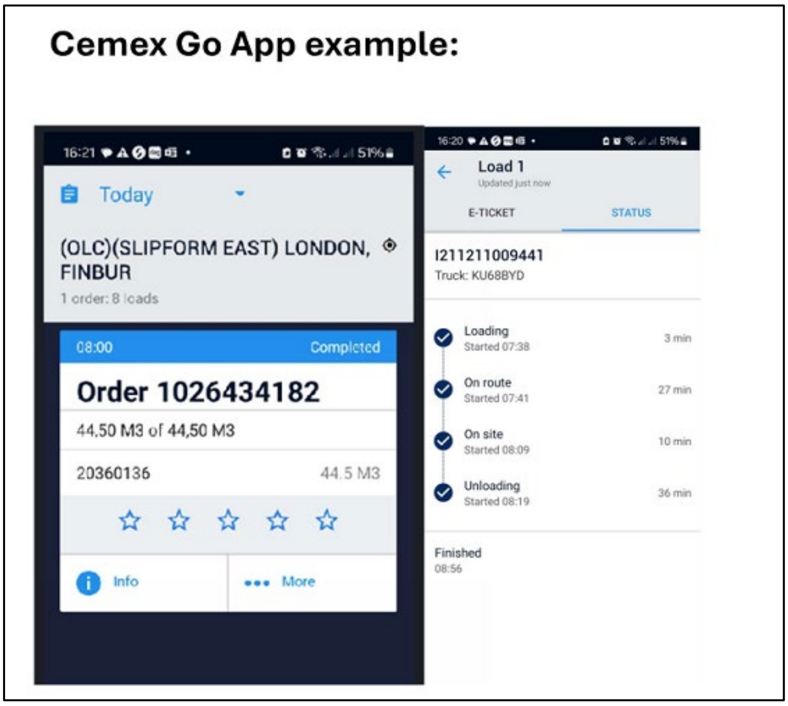


Figure 14 Cemex Go App Example

For instance, this digital solution enabled the team to monitor the concrete lorry from the batching plant and prepare the site in advance, facilitating immediate concrete discharge upon arrival. The concrete team began mixing the grout that lubricates the line as soon as the lorry was five minutes away, ensuring they were ready to pump the concrete immediately upon its arrival. With the digital solution implemented, the first delivery of the day was scheduled on the Cemex app for 7:30 AM. Subsequent deliveries were booked and digitally tracked to maximise the placing times, resulting in an overall improvement in cycle time for the shift.

By enhancing communication and implementing digital technology for tracking deliveries, the site team progressively reduced time wastage, ensuring a seamless process flow and maintaining operational efficiency.

Because of the above tactical solutions, the team refined their monitoring methods through continuous oversight of delivery times, placement/discharge times, and delays for each load. They maintained detailed daily performance logs – refer to *Figure 15 Concrete daily performance logs*-, based on data from both the Cemex app and on-site operations, and acted promptly when deviations were observed. The site team successfully adopted site-specific metrics that followed the principles outlined in the Measuring Construction Site Productivity: A Seven-step Framework for Success "Site-specific metrics are best identified, developed, and applied using the seven-step framework… Frequency of measurement (daily, weekly, monthly), Granularity (work package or activity level)… benchmarks from previous projects/available industry best practices…Identifying insights from the collected data in how productivity can be improved" (Measuring Construction Site Productivity: A Seven-step Framework for Success (2022), p. 22)

Supplier	Cemex			Concrete vo	59.5	Carpenters	8	Concrete daily performance								
Location	East core	Target placing	01:00:00	Climb rate	2400	Fixers	8									
Date	30 March 2022	Target delivery	01:00:00	TOC		Concrete Gang	19									
	Time requested on site	Adjustment in time	Registration	Volume M3	Time loaded	Time on route	Time on site	Interval	interval deviation	Travel duration	Unloading start	Unload start delay	Unloading finish	Discharge period	Total delay	Reason for delay
1	07:30		RX16WYF	7.5	07:07	07:17	07:48			00:31:00	07:56	00:08:00	08:49	00:53:00	00:01:00	
2	08:30		KX18KHW	6.5	08:07	08:08	08:40	00:52:00	-00:08:00	00:32:00	09:04	00:24:00	09:51	00:47:00	00:11:00	
3	09:30		KX18KHU	6.5	09:01	09:30	09:36	00:56:00	-00:04:00	00:06:00	09:51	00:15:00	10:28	00:37:00	-00:08:00	
4	10:30		RX16WSE	6.5	09:47	10:21	10:21	00:45:00	-00:15:00	00:00:00	10:28	00:07:00	11:18	00:50:00	-00:03:00	
5	11:30		RX16WYF	6.5	10:18	10:44	10:49	00:28:00	-00:32:00	00:05:00	11:24	00:35:00	12:01	00:37:00	00:12:00	
6	12:30		KX18KHW	6.5	10:49	11:29	11:29	00:40:00	-00:20:00	00:00:00	12:17	00:48:00	13:04	00:47:00	00:35:00	
7	13:30		RX16WSE	6.5	11:55	11:59	12:32	01:03:00	00:03:00	00:33	13:02	00:30:00	13:47	00:45	00:15:00	
8	14:30		RX16WYF	6.5	12:47	12:53	13:55	01:23:00	00:23:00	01:02	13:55	00:00:00	14:43	00:48	#VALUE!	
9	15:30		KX18KHW	6.5	13:43	13:48	13:14	-00:41:00	-01:41:00	-00:34	14:50	01:36:00	15:50	01:00	#VALUE!	

Supplier	Cemex			Concrete vo	31.5	Carpenters	8	Concrete daily performance								
Location	East core	Target placing	01:00:00	Climb rate	1500	Fixers	8									
Date	31 March 2022	Target delivery	01:00:00	TOC		Concrete Gang	19									
	Time requested on site	Adjustment in time	Registration	Volume M3	Time loaded	Time on route	Time on site	Interval	interval deviation	Travel duration	Unloading start	Unload start delay	Unloading finish	Discharge period	Total delay	Reason for delay
1	07:30		RX16WYF	7.5	07:30	07:39	08:09			00:30:00	08:20	00:11:00	09:04	00:44:00	-00:05:00	
2	08:30		KX67RUO	6	08:25	08:28	08:55	00:46:00	-00:14:00	00:27:00	09:22	00:27:00	10:05	00:43:00	00:10:00	
3	09:30		RX14TEO	6	09:24	09:59	09:59	01:04:00	00:04:00	00:00:00	10:11	00:12:00	11:26	01:15:00	00:27:00	
4	10:30		KX67RKJ	6	09:56	10:00	10:15	00:16:00	-00:44:00	00:15:00	11:34	01:19:00	12:20	00:46:00	01:05:00	
5	11:00		RX16WYF	6	10:50	10:55	10:15	00:00:00	#VALUE!	-00:40:00	12:34	02:19:00	13:20	00:46:00	#VALUE!	Stop for plates

Figure 15 Concrete daily performance logs

Further analysis of concrete daily performance logs revealed significant variability in the timing of the last delivery to the site -refer to *Figure 16 Last delivery to site 2-week analysis*-. It was determined that on eight out of fifteen days, the site team had the capacity to accommodate an additional delivery. This could have increased output, based on the ideal last delivery time being around 14:45, assuming a site finish time of 19:00 with 90 minutes for cleaning and 210 minutes for curing.

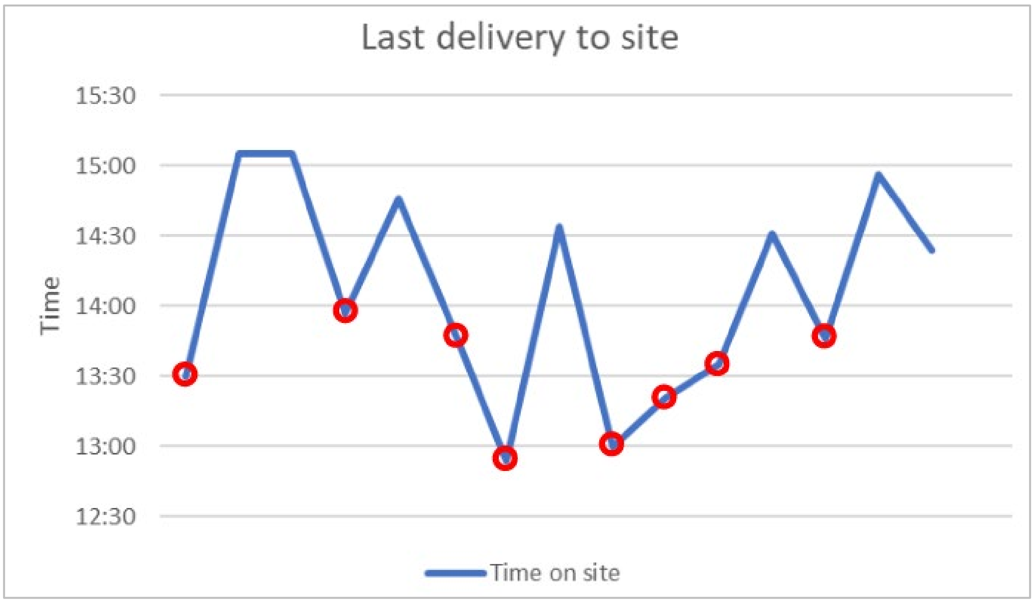


Figure 16 Last delivery to site 2-week analysis

Recommendations

This case study offers lessons that can be applied to future construction projects. It includes strategies for enhancing construction efficiency from the beginning through early engagement in design and collaboration with Morrisroe Ltd, which was crucial in ensuring the buildability of the design. This approach resulted in a design suited for construction and delivery that aligns with the project's program constraints.

Efficient planning of construction methodologies for slipform cores, incorporating advanced engineering techniques such as the installation of embed plates at elevated levels, illustrates the advantages of adopting engineering solutions aimed at enhancing operations. This resulted in improved production rates that far exceeded planned rates.

Identifying and addressing productivity disruptors was essential for maintaining project efficiency and adhering to deadlines. One effective strategy involved the diligent monitoring of cycle times and other relevant metrics such as deliveries times and curing times. When there was a change in cement types, the project delivery team's ability to swiftly respond and resolve issues was critical in ensuring the project remained on schedule. Furthermore, identifying and mitigating time wastage, such as delays in concrete deliveries, proved to be invaluable. By utilizing digital tools to obtain real-time updates on concrete operations, the team improved predictability, ensuring process flow and minimizing disruptions.

All the approaches and strategies implemented in the project ensured continued improvement of construction site productivity and confirm the findings from other pilot projects captured in Measuring Construction Site Productivity: A Seven-step Framework for Success " Our findings from the pilot projects suggest that construction site productivity can be significantly improved through increased offsite manufacture and standardised design solutions, increased automation of the building process, targeted and considered use of digital technologies, improved collaborative activity planning and logistics management, improved training and upskilling of the workforce, and reduced waste" (Measuring Construction Site Productivity: A Seven-step Framework for Success (2022), p. 3).

Case Study No 2: Enhancing Productivity and Efficiency in Cladding Operations – Results of a Pilot Site Study

Acknowledgements

Ashan Senel Asmone – Research Associate, University of Cambridge
Danny Murguia – Senior Research Associate, University of Cambridge
Javier Lopez – Strategic Digital Programme Manager, Sir Robert McAlpine
Jas Degon – Senior Planner, Sir Robert McAlpine
Shayne Gee – Cladding Manager, Sir Robert McAlpine.

Overview

The 1 Broadgate project represents a major private-sector commercial office development in central London, with an estimated value of approximately £300 million. During its construction phase, the site was examined to evaluate construction productivity in standard projects. The assessment aimed to identify the fundamental causes of productivity disruptions and enhancements, in alignment with Phase 2 of The Construction Productivity Taskforce's Pilot Sites study workstream.

This case study provides an in-depth analysis of cladding operations for the Broadgate project which comprises the installation of unitised façade panels by Focchi Ltd, aiming to improve productivity in the construction industry through innovative techniques and collaboration.

The measurement and analysis of the collected data focus on productivity metrics—such as installation rates, cycle times, and delivery durations—during the delivery and installation of cladding units from March to July 2024. This approach follows the methodology established during Phase 1 of the Construction Productivity Taskforce's Pilot Sites study workstream and aligns with the Seven-Step Framework for Measuring Construction Productivity (2022) and outlined in Measuring Construction Productivity across Projects: Multilevel Three-Dimensional Framework (2024).

> "Improving productivity is the key to driving transformational change in the construction sector. Higher productivity reduces costs, increases production, and enables the most effective use of available resources which is at the heart of sustainable construction. To be able to improve, it is essential to measure and compare."
> (Trust and Productivity: Private sector construction playbook (2022), p. 65)

Background

1 Broadgate is a landmark commercial office development within British Land's Broadgate regeneration initiative. The project required the installation of approximately 2,696 unitised façade panels, which were prefabricated offsite and delivered just-in-time to support efficient onsite assembly in line with a kit-of-parts construction approach.

Despite early challenges, strategic planning and disciplined execution ensured the on-time completion of all façade unit installations, with no reported delays. The project faced significant logistical constraints—including restricted urban access, crane dependency, and limited onsite storage—which necessitated a **delivery model optimised for productivity**, safety, and traceability.

This case study demonstrates how the delivery model at 1 Broadgate significantly outperformed established UK benchmarks for high-rise unitised cladding, which typically range from 10 to 15 panels per day, as reported in industry productivity studies such as *Productivity in Construction: Creating a Framework for the Industry* (CPA, 2021). Between March and July 2024, the project achieved an **average daily installation rate of 17 units**, as illustrated in *Figure 17 Daily Installation of Panels and Variability*. On the highest-performing days—representing the upper quartile of productivity—the rate reached 23 panels per day, with best performance between **23 and 38 panels per day** recorded during April 2024.

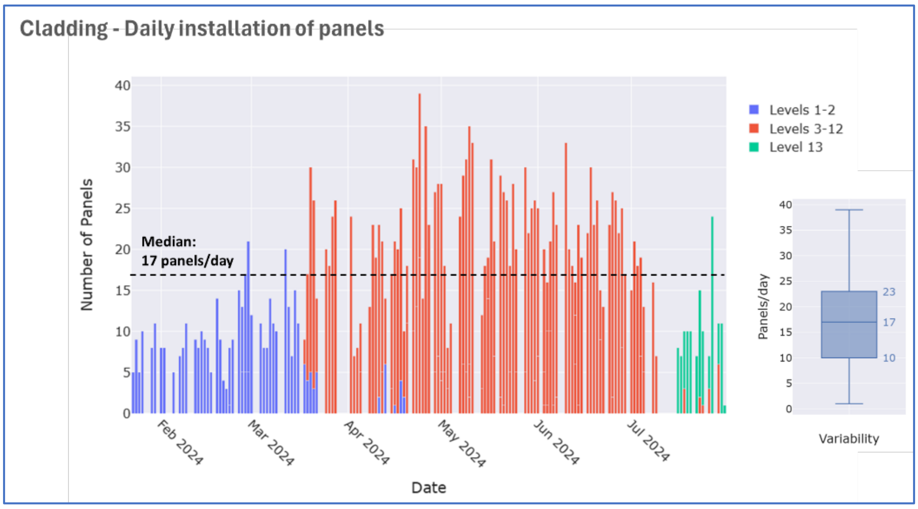


Figure 17 Daily Installation of Panels and Variability

Flowline analysis of the cladding installation depicted in *Figure 18 Flowlines for cladding installation* demonstrates a steady and continuous installation sequence with limited variance across most levels. While the initial progression from L0 to L2 shows a slower ramp-up—indicative of early-stage learning curves or site readiness constraints—the installation rhythm stabilised rapidly from L3 onward. While the original programme outlined primarily finish-to-start relationships between floor levels, the actual installation sequence demonstrated strategic overlaps across floors. This overlapping approach maintained workflow continuity and contributed to faster progress ultimately outperforming the planned schedule and reducing the risk of significant delays. This performance contrasts with the fragmented, stop-start patterns often observed in façade works and underscores the effectiveness of integrated logistics planning and stable labour deployment strategies.

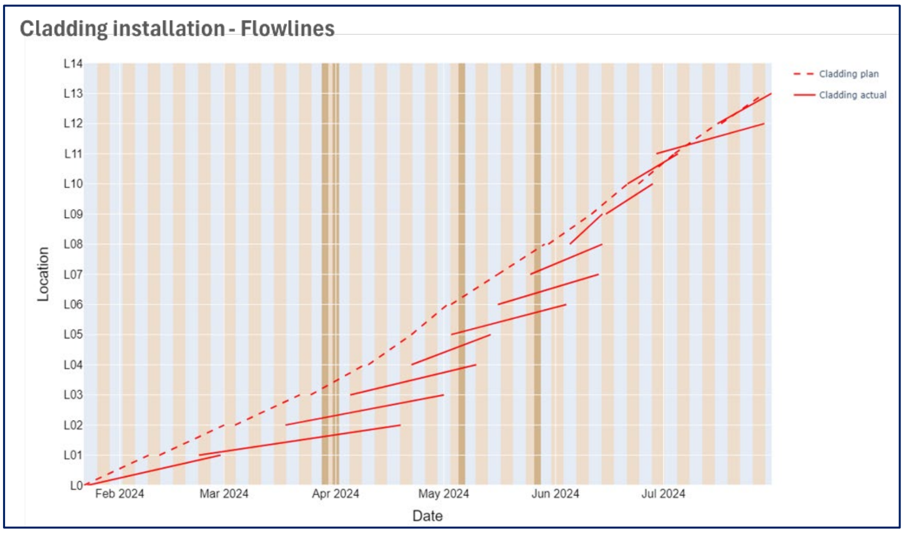


Figure 18 Flowlines for cladding installation

This study examines the factors that led to the project's success and outlines how the delivery team effectively implemented strategies to improve productivity while minimizing disruptions. The strategies employed by the delivery team included early-stage integration of logistics planning to align deliveries with specific installation requirements, as well as the incorporation of digital tracking tools, which became essential elements of the project strategy.

Application of Advanced Logistics Solutions to Maximise Construction Efficiency.

In consideration of the dense urban environment and the scale of the façade package, logistics were integrated early in the design process to enable a more **cohesive delivery strategy**. Logistics were treated as an essential aspect of design rather than a limitation. From the beginning, the project team developed **specific logistical solutions** to optimise the delivery and vertical distribution of cladding panels, coordinate sequencing with concrete slab installation, reduce dependence on the tower crane, and address potential productivity issues such as adverse weather.

> "Teams will need to rethink the logistics solutions employed on construction projects to meet the new business models driven by highly systemised solutions and disruptive technologies."
> (Trust and Productivity: Private sector construction playbook (2022), p. 33)

Logistics solutions, designed to support the **building-kit-of-parts systemized approach** for prefabricated cladding panels, were focused on decoupling vertical material distribution from the point-of-installation processes. This strategy allowed the team to tailor delivery and staging methods to the unique requirements of each cladding zone/level, addressing factors like access points, building elevations, and specific installation schedules. Depicted in *Figure 19 Logistics Solutions: Stillage Unloading and Vertical Distribution Strategy*, the approach was structured around **multiple logistics cases** each carefully calibrated to optimize site-specific conditions such as material handling constraints, installation equipment needs, and floor availability.

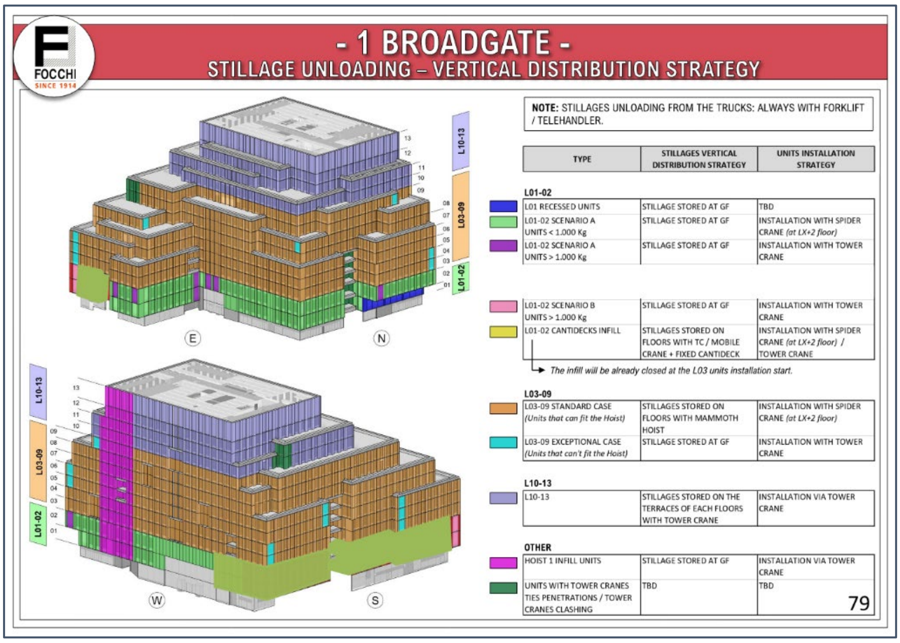


Figure 19 Logistics Solutions: Stillage Unloading and Vertical Distribution Strategies

To assess the relevance of logistics solutions to installation performance, methodologies for cladding delivery were categorised into three distinct **distribution and installation scenarios** based on their similar characteristics and timeframes:

- **Scenario 1 (Levels 1–2; 23 Jan until 18 March 2024):** Installation followed a traditional linear sequence with limited flexibility consisting of mixture of tower crane and spider crane hoisting with cladding units stored at ground-level.
- **Scenario 2 (Levels 3–12; 19 March until 9July 2024):** The distribution was performed using high-capacity mammoth hoist cladding units, which delivered to designated stillage zones on each floor. The installation process on each floor employed floor-mounted launching tables and a spider crane for positioning each unit.
- **Scenario 3 (Level 13; 16-31 July2024):** Final terrace levels were served by manual handling combined with tower crane assistance.

As illustrated in *Figure 17 Daily Installation of Panels and Variability*, The strategy enabling distribution and installation for scenario 2 (Levels 3–12) introduced a step change in productivity through a logistics model that facilitated consistent, high-volume façade delivery. Compared to Strategies 1 and 3, which relied on centralised tower crane operations and exhibited sporadic daily outputs, Strategy 2 achieved a **peak installation rate of 38 units/day, with best performant (top quartile) between 26 and 38 panels/day**. This performance reflects a stable and predictable flowline rhythm that outperformed industry benchmarks. The Construction Productivity Taskforce affirms that "Tracking the movement of components and inventory management in real time will become essential and we are likely to see a

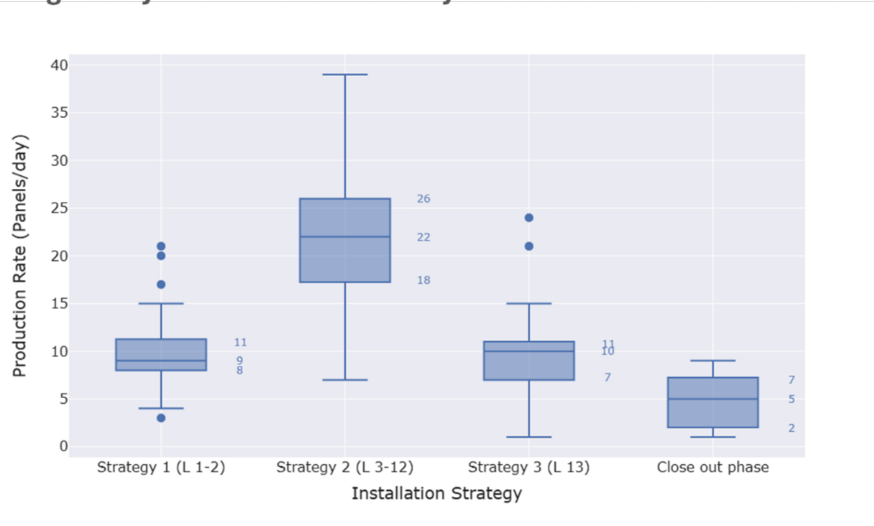
growth in the use of consolidation centres to manage the flow of material to site and last-mile logistics" (Trust and Productivity: Private sector construction playbook (2022), p. 33), and Strategy 2 exemplifies this by enabling simultaneous cladding operations on multiple floors with minimal disruption.
The logistics solution applied to scenario 2 marked a transformative approach by establishing a decentralised, **floor-by-floor façade assembly line**. Prefabricated panels were vertically distributed using the Mammoth Hoist in pre-sequenced stillages, then transferred horizontally via **launching tables** as depicted in *Figure 20 Distribution Stillages on Floors (L3-12)*.

Figure 20 Distribution Stillages on Floors (L3-12)

installed using **spider cranes** at the slab edge. This method not only decoupled cladding installation from the tower crane, but also eliminated sequential dependencies, enabling up to **three floors to operate concurrently** as depicted in *Figure 18 Flowlines for cladding installation.*

Scenario 2's logistic approach stands as a demonstrable application of logistics-led design in achieving programme certainty and productivity excellence. As demonstrated in *Figure 21 Cladding Production Rate Variability based on Logistics Scenarios*, this represents a **140% improvement compared to Strategies 1 and 3**, which exhibited substantially lower production rates with median values of 9 units/day and 10 units/day for Strategy 1 and Strategy 3 respectively.

Cladding – Daily Installation Variability based on the Installation Strategy



	1BG (levels 1-2)	1BG (levels 3-12)	1BG (level 13)	1BG (Close out)
Number of panels	406	1884	149	257
Avg daily number of workers	26	55	63	69
Avg labour productivity (panels/wh)	0.04	0.05	0.02	0.01
Avg production rate (panels/day)	9	22	10	5

Figure 21 Cladding Production Rate Variability based on Logistics Scenarios

While Strategy 2 delivers significantly higher productivity with a median of 22 units/day, it also introduces greater variability (production rates ranging from 18-26 units/day) compared to the more consistent performance of Strategies 1 (8-11 units/day) and 3 (7-11 units/day) suggesting that while Strategy 2 offers higher potential production rates, it may require more robust management controls to maintain consistent performance and mitigate the risk of productivity fluctuations.

This trend is further substantiated by the labour productivity data shown in *Figure 22 Labour Productivity Variability based on logistics scenarios*. Strategy 2 not only achieved the highest median labour productivity at 0.05 panels/worker-hour, but also demonstrated a wider distribution, with values ranging from 0.03 to 0.06. This variability, while indicative of fluctuating performance, underscores the strategy's capacity to accommodate higher outputs when conditions and coordination align effectively. In comparison, Strategy 1 exhibited a lower and more concentrated productivity range (0.03–0.05), suggesting steadier, yet limited efficiency gains. Strategy 3, meanwhile, showed the lowest and narrowest productivity range (0.01–0.02), reflecting both constrained output and limited adaptability. The greater spread in Strategy 2 highlights the importance of aligning logistics execution with workforce capability—offering the highest upside, but demanding tighter coordination, responsive supervision, and contingency planning to manage peak demands and ensure reliable performance across the programme.

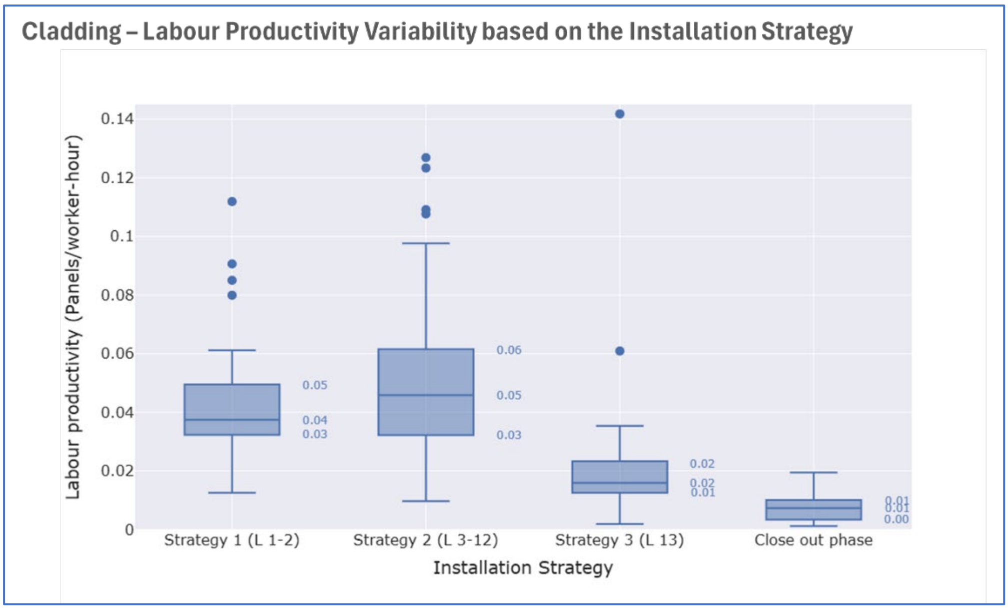


Figure 22 Labour Productivity Variability based on logistics scenarios

Examining Strategy 2's features reveals several key factors that enabled its outstanding productivity: maximizing vertical area utilization through level-based workflow autonomy, reducing weather-related downtime, and streamlining labour productivity.

Benefiting from this logistics-driven solution where each floor operated independently, dedicated stillage areas were assigned to each active level, allowing installation teams to work concurrently without relying on tower crane availability. This autonomous approach facilitated simultaneous installation across **up to three floors**, where productivity consistently reached 15-35 units per day from April through June 2024, significantly outperforming the lower rates of 5-15 units seen in Levels 1-2 (February-March) and Level 13 (July), as clearly illustrated in *Figure 17 Daily Installation of Panels and Variability*.

The overlapping workflow methodology enabled installation to be maximized with **multiple installation fronts operating in parallel**. A prime example of this approach is visible in *Figure 18 Flowlines for cladding installation*, where Levels 3, 4, and 5 show concurrent installation activities during w/c 6th May 2024, with daily productivity rates frequently exceeding 24 units daily across these floors. As shown, this parallel processing also enabled the **compression of floor cycle times** for Level 3 and Level 4 to five and three weeks respectively. Both processes were executed concurrently to expedite the overall installation and ensure adherence to the planned schedule.

Labour deployment under Strategy 2 (Levels 3-12) achieved the highest recorded efficiency, with best performance (upper quartile) ranging 0.06-0.09 units/worker-hour as depicted in *Figure 22 Labour productivity and Daily Output Rates by Scenarios*, significantly outperforming the best performance rates of 0.05-0.06 units/worker-hour and 0.02-0.03 units/worker-hour seen in Strategy 1 and 3 respectively. The eight-person installation team per floor employed during Strategy 2 demonstrated **superior labour efficiency compared to the larger crews observed in Strategies 1 and 3**. These smaller, more specialized teams benefited from consistent task repetition, reduced wait times, and better synchronization with panel availability due to decentralized staging.

Figure 23 Labour productivity and Daily Output Rates by Scenarios demonstrates a distinctive pattern where scenario 2 (Levels 3-12) not only achieved the highest panel installation rates (reaching up to 40 panels/day) but also maintained stronger labour productivity across higher production volumes compared to alternative implementation methodologies. This performance differential is evidenced by the concentration of data points extending into the high-output region of the graph (above 15 panels/day and above 0.04 panels/worker-hour), indicating scenario 2's superior capacity for volume production while maintaining acceptable workforce efficiency metrics.

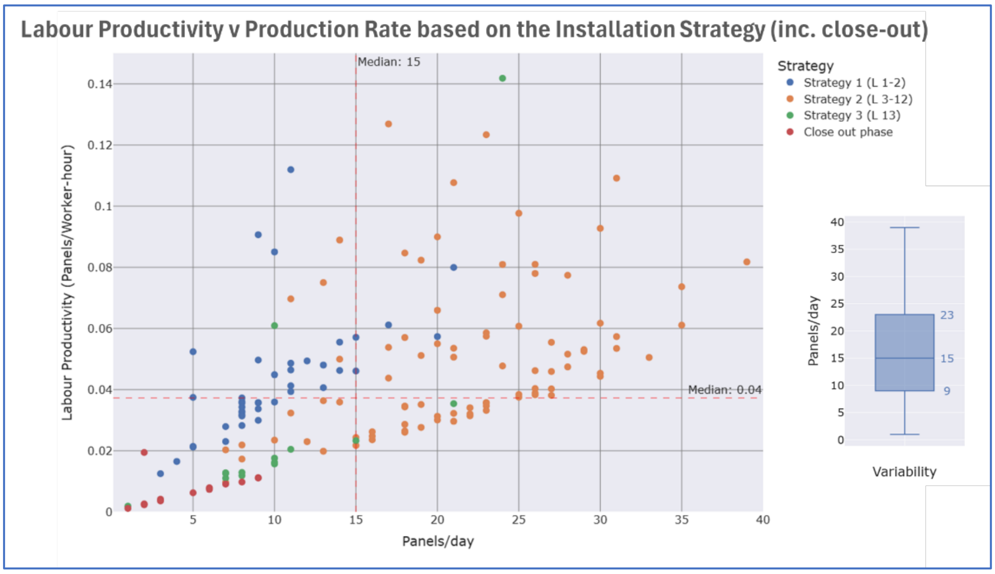


Figure 23 Labour productivity and Daily Output Rates by Scenarios

When comparing this performance with Project A—a comparable commercial development featuring similar installation characteristics to 1 Broadgate—it becomes evident how logistics strategy selection directly influences both production rates and labour efficiency. Project A demonstrates notably higher labour productivity, particularly within the lower production range of 5 to 20 panels per day, where the best-performing data points fall between 0.04 and 0.17 panels per worker-hour. This trend, as shown in *Figure 24 Labour Productivity v Production Rate (Project A v 1BG)*, highlights a potential trade-off between labour efficiency and daily output volume, suggesting that the Project A delivery model may optimise workforce usage at the expense of throughput.

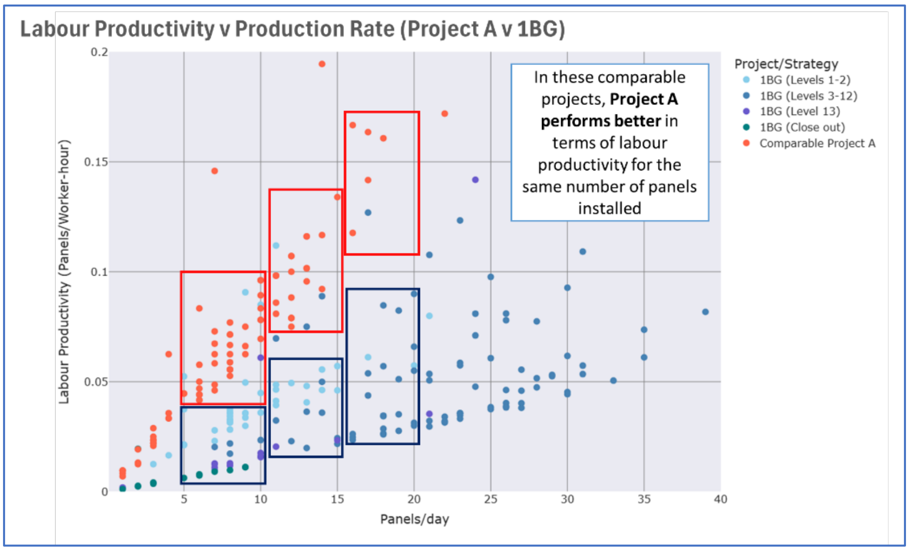


Figure 24 Labour Productivity v Production Rate (Project A v 1BG)

However, a critical contextual factor must be acknowledged: a large portion of cladding panels used in Project A were approximately 3 metres long, meaning each unit covered a greater façade surface area. This could partially explain the elevated labour productivity rates as depicted in *Figure 25 Cladding Labour Productivity Variability*, as fewer panels were required to achieve the same progress. In contrast, Strategy 1 (Levels 1–2) exhibits both low production rates (typically under 15 panels/day) and labour productivity values concentrated below 0.05 panels/worker-hour, indicating limited efficiency. Strategy 3 (Level 13) performs similarly, with modest output and marginally better productivity, but remains constrained in both scale and consistency.

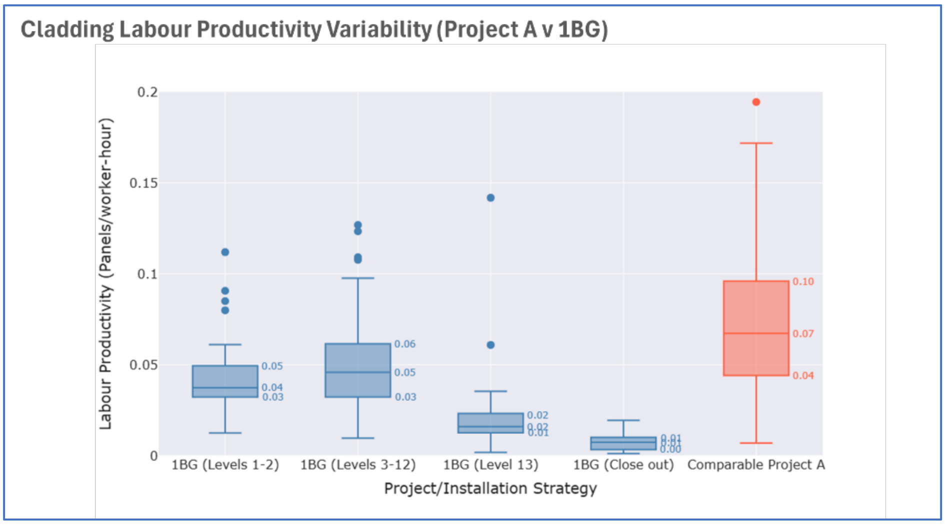
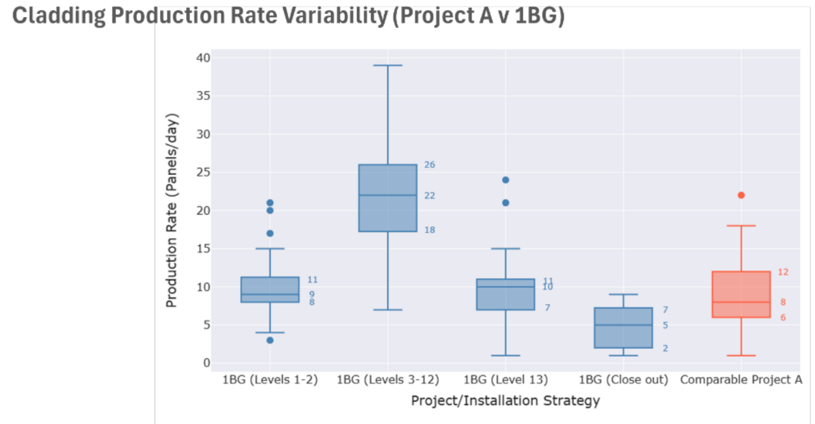


Figure 25 Cladding Labour Productivity Variability

Scenario 2 (Levels 3–12), however, stands out for its balanced and scalable performance. It consistently achieves higher production rates (often between 20–35 panels/day) while maintaining labour productivity within a competitive range (0.03–0.12 panels/worker-hour). This positions Strategy 2 within a high-performance operating zone, where both output volume and workforce efficiency align. Despite not matching the top labour productivity coefficients seen in Project A as demonstrated in *Figure 25 Cladding Labour Productivity Variability*, Scenario 2 delivers approximately 2–3 times the daily output and demonstrates more scalable logistics execution—an essential attribute for large-scale panel installation projects.

In summary, while Project A demonstrates higher labour productivity at lower daily output levels—likely influenced by the use of larger cladding panels that cover more façade area per unit—the 1BG Scenario 2 strategy proves more effective in delivering consistent, high-volume performance as depicted in *Figure 24 Cladding Production Rate Variability*. Its ability to sustain elevated production rates – over 20 units a day- while maintaining competitive labour efficiency highlights a more scalable system. This makes Scenario 2 the preferred approach for large-scale façade installations with over 2,000 units where speed is critical to project success.



	1BG (levels 1-2)	1BG (levels 3-12)	1BG (level 13)	1BG (Close out)	Project A
Number of panels	406	1884	149	257	705
Avg daily number of workers	26	55	63	69	13
Avg labour productivity (panels/wh)	0.04	0.05	0.02	0.01	0.07
Avg production rate (panels/day)	9	22	10	5	8

Figure 26 Cladding Production Rate Variability

Strategies to Mitigate Weather Disruption in High-rise Cladding Installation.
Another factor contributing to the outstanding performance of the logistic solution adopted for Strategy 2 (Level 3 to 12) was its remarkable resilience to **weather disruption**, a major source of variability in high-rise cladding. Because installation was performed using floor-mounted spider cranes, rather than weather-sensitive tower cranes, operations remained continuous during periods of moderate wind.

> "Unhealthy site characteristics such as noise, dust, and vibration as well as poorly designed materials, logistics and access, which give rise to unnecessary manual handling, will need to be considered much earlier in the design and planning phase".
> (Trust and Productivity: Private sector construction playbook (2022), p. 54)

Historical wind speed data matched against daily output records showed minimal correlation between weather conditions and productivity under Strategy 2. On days with wind speeds above the operational limits of tower cranes (typically >38 km/h), façade installation continued uninterrupted. This contrasts with Strategy 1 and Strategy 3, which experienced partial or complete stoppages during similar conditions. *Figure 23 Correlation Between Output and Weather Disruption* confirms that output under Strategy 2 remained constant during days of adverse conditions specifically during April 2024, compared to other strategies.

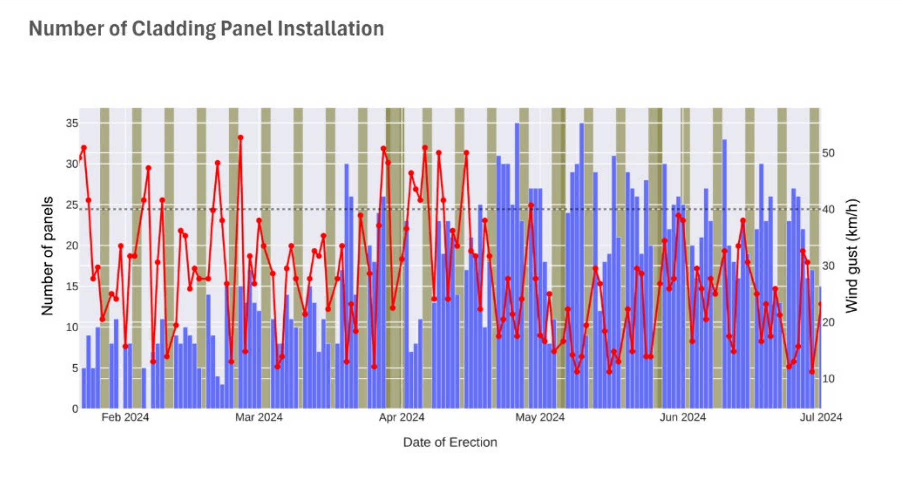


Figure 27 Correlation Between Output and Weather Disruption

Evidence of this, during May and June 2024—when Strategy 2 was fully implemented—installation rates consistently reached 25-35 panels per day even during periods of fluctuating wind conditions between 15-40 km/h. This stands in stark contrast to February and March 2024 (Strategy 1), where panel installation rarely exceeded 15 units per day despite similar wind patterns. This evidence demonstrates how the decentralized, floor-based installation approach effectively **decoupled productivity from weather variables** that typically constrain traditional high-rise cladding operations.

Further analysis including labour productivity exhibits a clear pattern when analysed against windage conditions. Data points with wind speeds below 40 km/h (orange dots) achieved productivity rates up to 0.13 pieces/worker-hour, with multiple instances exceeding the overall median productivity of 0.04 as depicted in *Figure 24 Cladding Production Rates vs Labour Productivity*. Most notably, the highest productivity rates occurred during periods of moderate wind (below 40 km/h), with several data points reaching 0.08-0.13 pieces/worker-hour even as production volumes exceeded the median of 17 pieces/day.

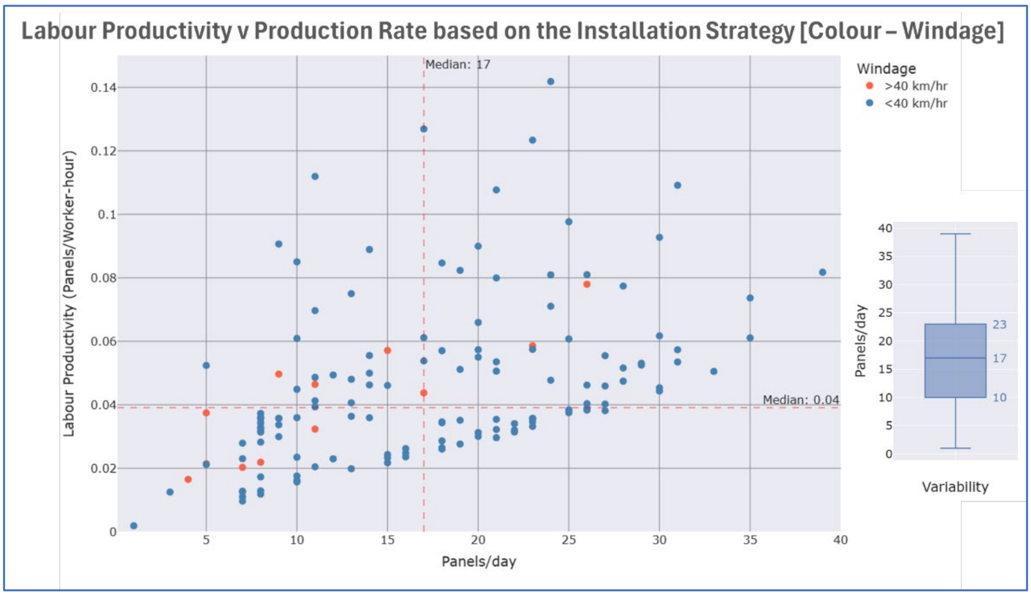


Figure 28 Cladding Production Rates vs Labour Productivity

Utilisation of Physical and Digital Tagging for Effective Panel Unit Delivery.

An essential aspect of the successful delivery of the cladding installation was the use of **digital tracking systems** for each façade panel as per *Figure 25 Storage and Shipping Process*. This allowed for real-time tracking, verification, and progress management from the moment the panels were fabricated, stored in the Focchi yard, through shipping, and finally delivery to their installation on-site.

> "The use of digital technologies to collect data in real time should be considered from the outset of any productivity study. Particularly, identifying and developing solutions to collect labour and plant utilisation across the whole project.". *(Measuring construction site productivity: A seven-step framework for success (2022), p. 50)*

Each panel was assigned a unique asset ID at the point of manufacture, and QR labels were used to scan panels at every key stage in their delivery journey — from fabrication to on-site staging to final installation. This system ensured that panels could be traced throughout the entire supply chain, preventing material mismatches or misplaced deliveries.

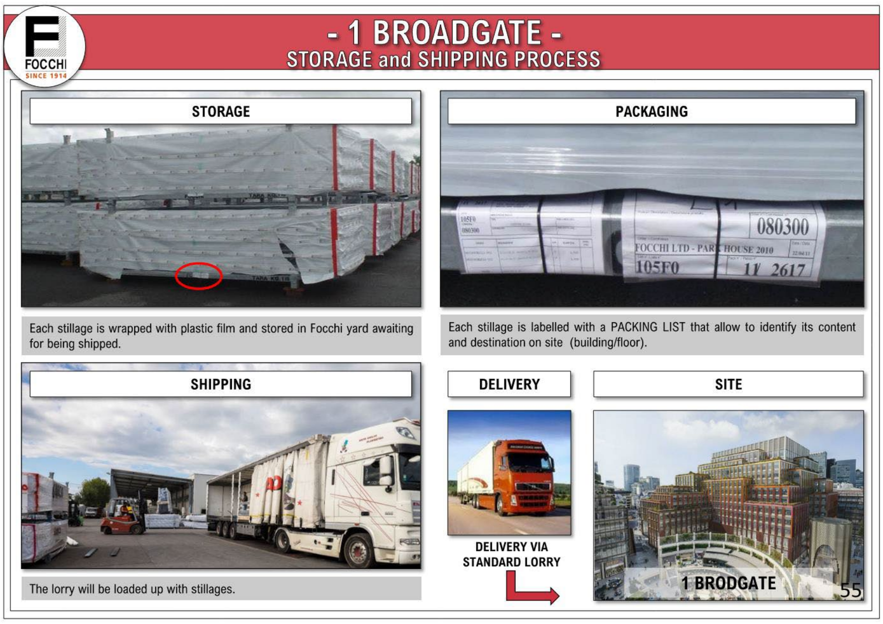


Figure 29 Storage and Shipping Process

Physical asset tagging combined with digital asset tagging, including FIN/CE codes, ensured traceability and enabled real-time validation of panel location, sequence, and installation status. On-site operatives scanned panels upon floor delivery and again at the point of placement, synchronising data with the delivery system and updating progress records as per *Figure 26 Construction Records including FIN/CE Codes*. This digital assurance model aimed to reduce installation errors, streamline quality control, and improve delivery performance visibility across the team.

Figure 30 Construction Records including FIN/CE Codes

This asset tagging strategy underpinned a digitally integrated workflow across all stages: fabrication, consolidation, delivery, floor-level staging, installation, and QA. Every unit was traceable, both physically and digitally, ensuring correct placement and auditability at every step.

Recommendations

Based on 1 Broadgate's performance, the following strategic recommendations are proposed:

1. **Integrate Logistics Planning from the Outset**: Logistics design should be formalised during early design stages to ensure delivery and installation methods are structurally and programmatically aligned. At 1 Broadgate, the integration of hoist access, floor-level staging, and flowline logistics allowed the team to eliminate typical site bottlenecks. Aligning façade logistics with the concrete frame schedule enabled uninterrupted installation as soon as each level became accessible, avoiding costly start-stop cycles.
2. **Adopt Decentralised Installation Models**: The shift from tower crane dependency to decentralised logistics at 1 Broadgate—specifically through the use of Mammoth Hoist, launching tables, and spider cranes—created autonomous floor-by-floor workflows. This approach, which functioned as a vertical façade assembly line, allowed up to five floors to operate concurrently. It removed sequential task dependencies and unlocked vertical area utilisation, leading to compressed floor cycles (as low as three weeks) and peak productivity of 35 panels/day. Replicating this model in other projects can support programme resilience and reduce interface delays between logistics and installation trades.
3. **Implement Physical and Digital Asset Tagging**: All façade panels at 1 Broadgate were tagged with unique QR codes that tracked the units from fabrication through to on-site installation. This digital tagging was used on site to verify correct panel sequencing, floor allocation, and installation completion. The system supported real-time QA documentation and significantly reduced instances of rework, non-conformance, and material misplacement. Projects should implement similar digital workflows to improve traceability, ensure programme alignment, and facilitate transparent closeout procedures.
4. **Logistics Solution Resilient to Weather Disruption**: Weather-related delays—particularly wind speed limits for tower crane use—are a significant source of productivity loss on high-rise sites. At 1 Broadgate, Strategy 2's avoidance of tower crane reliance allowed cladding to continue uninterrupted, even during periods of elevated wind. Internal staging and floor-mounted spider cranes insulated the programme from external disruption. Future projects should prioritise logistics solutions that enable sheltered, floor-level operations to ensure productivity continuity under typical UK weather patterns.

Table of Figures