CS501440

Addressing the Productivity Crisis in Construction

Jaimie Johnston MBE
Bryden Wood

Learning Objectives

- Learn about what productivity really means in construction, and why comparisons to, for example, manufacturing aren't always relevant.
- See which approaches, digital tools, and automation technologies are having the greatest impact in transforming outcomes.
- Learn about procurement approaches, risk management, and delivery models that are bringing clients closer to their supply chains.
  Have a better understanding of how the future of construction will need to be shaped, and who the key players will need to be.

Description

The productivity crisis is well known, and numerous industry reports identify the issues and scale of the opportunity. Boosting productivity is the greatest chance the sector has to transform itself-it's the one lever that would automatically help address sustainability, the skills gap, rising costs, and pressure on resources. This session will cover dramatic advances in business outcomes that are now being made by combining algorithmic and computational design, industrialized construction, use of robotics, and on-site automation. This combination if already demonstrating how schedules can be halved using far fewer operatives, achieving higher quality and safety, with lower carbon. However, this has required new relationships and procurement strategies. As well as showing real-world examples, this session will also consider how roles, business models, incentives, and value propositions will need to adapt if the industry is to make the necessary change.

Speaker(s)

Jaimie joined Bryden Wood shortly after its formation in 1995. Jaimie leads on the application of systems to the delivery and operation of high performing assets. He is a leading authority on the platforms approach to design for manufacture and assembly (P-DfMA) and works on new data-led, digital workflows for government and private sector clients in the UK, US, Europe and Asia.

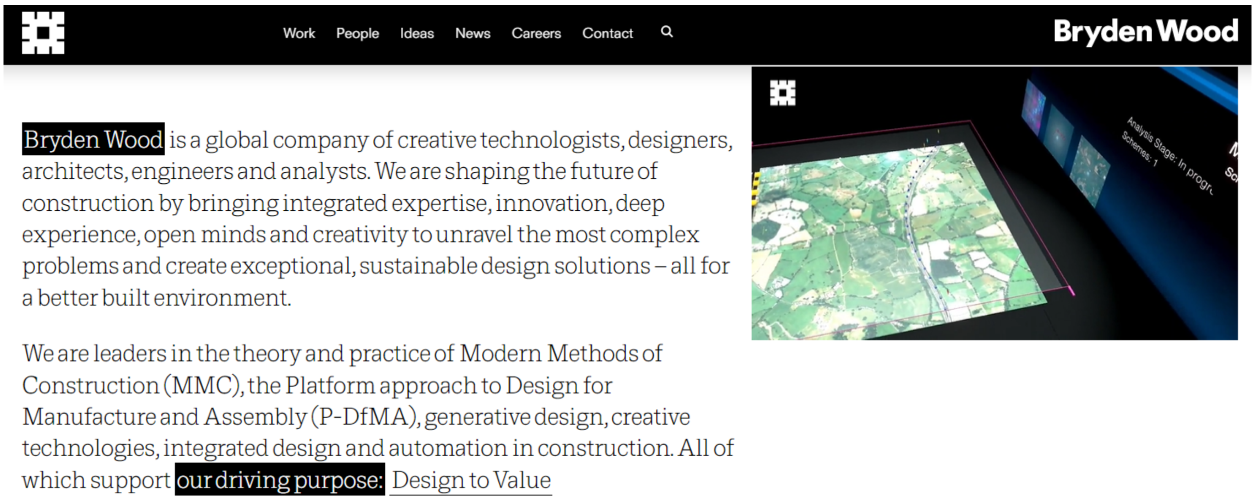
Jaimie is the author of the benchmark strategy documents, 'Delivery Platforms for Government Assets' (2017, republished 2021), and 'Platforms: Bridging the gap between construction and manufacturing' (2018). These are now the foundation for the UK Government's drive to create a more productive, value-driven construction sector.

Jaimie was a contributor to the UK Government's 'Transforming Infrastructure Performance: Roadmap to 2030' and 'Construction Playbook'. He is also the Platform Design Lead for the Construction Innovation Hub.

Jaimie was awarded an MBE by the Queen in 2021 for Services to Construction.

About Bryden Wood

Bryden Wood are leaders in the theory and practice of Industrialized Construction and Modern Methods of Construction, the Platform approach to Design for Manufacture and Assembly (P-DfMA), generative design, creative technologies, integrated design and automation in construction. All of which support our driving purpose: Design to Value.



Bryden Wood is a global company of creative technologists, designers, architects, engineers and analysts. We are shaping the future of construction by bringing integrated expertise, innovation, deep experience, open minds and creativity to unravel the most complex problems and create exceptional, sustainable design solutions – all for a better built environment.

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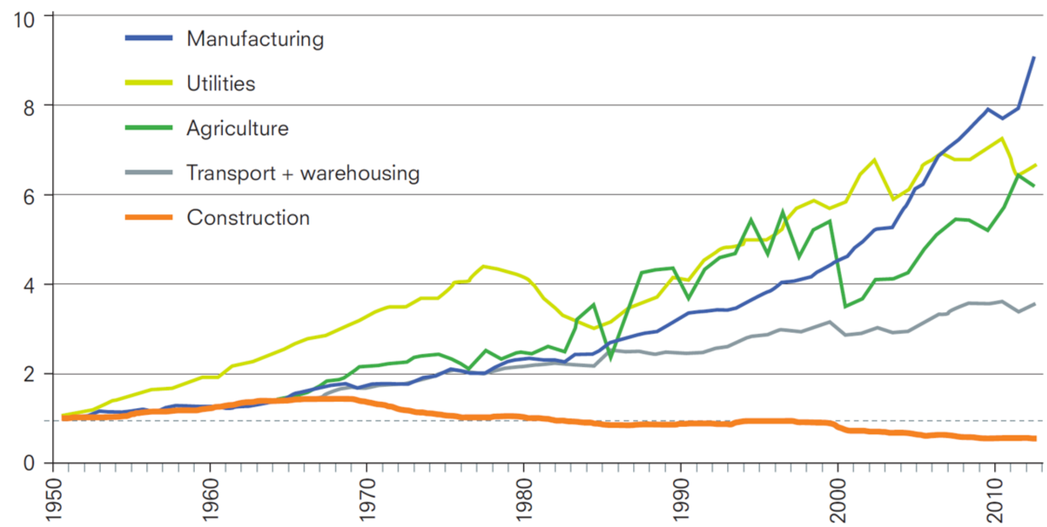
Find out more about Bryden Wood here https://www.brydenwood.com/

Defining 'productivity' in construction

Construction's productivity issue is well known – versions of the graph below have appeared in numerous reports over a number of years (this version was taken from the Construction Users' Round Table 'Managing Construction Productivity' committee https://www.curt.org/committees/managing-construction-productivity/). It shows a flatline in construction productivity over decades, while that in other sectors shows reasonably consistent gains. Other studies, notably McKinsey and Company's 'The Construction Productivity Imperative' show that construction continue to offer poor value to owners, with a significant proportion of projects running late, over budget, or both. Data from a UK Government's analysis of its project pipeline reveals that poor productivity is the number one cause of this.



But first let's look at how productivity is measured. The graph shows gross value add per employee. This is defined by the increase in value between say some raw materials and the finished product, and the amount of labour required to make the transition.

As a result, sectors such as pharmaceuticals have traditionally had an advantage here: they could take relatively low-cost bulk materials and process them into mass-produced but highly valuable drugs so the value-add was immediately very large (although this is changing with the increasing use of small batches and more highly targeted medicines).

However, construction doesn't conform to this model for a number of reasons, so we need to think slightly differently about productivity for construction; identifying more meaningful ways to measure our productivity and manufacturing-led approaches to unlock greater levels of it.

Construction can become manufacturing-led, but two fundamentals of construction mean we will never look like manufacturing:

1. <u>Cost density</u>

Built assets will never become as cost dense as manufactured products and therefore require different approaches.

Cost density is the compression of value into the least amount of space. The 'cost density' of products that are manufactured (phones, cars, aeroplanes) is very high – they are typically designed to maximize functionality in the smallest, lightest volume possible. (For instance, the volume of an iPhone 12 is 0.00007761897m³, at ~£849 this is £10.9 million/m³)

By contrast, built assets are mostly made up of:

- Air;
- Commodity/cheap materials such as concrete, steel, timber and plasterboard (e.g. concrete is ~£75/m³, so ~145,000 times less cost dense than an iPhone).

And while manufacturing seeks to reduce weight wherever possible, buildings require a certain amount of mass for acoustic and vibration performance i.e. buildings are inevitably bulky and heavy.

2. Scale

The object in manufacturing is invariably smaller than the process. The object in construction is bigger than the process. We will never fully overcome this fundamental difference to achieve the same level of manufacturing process.

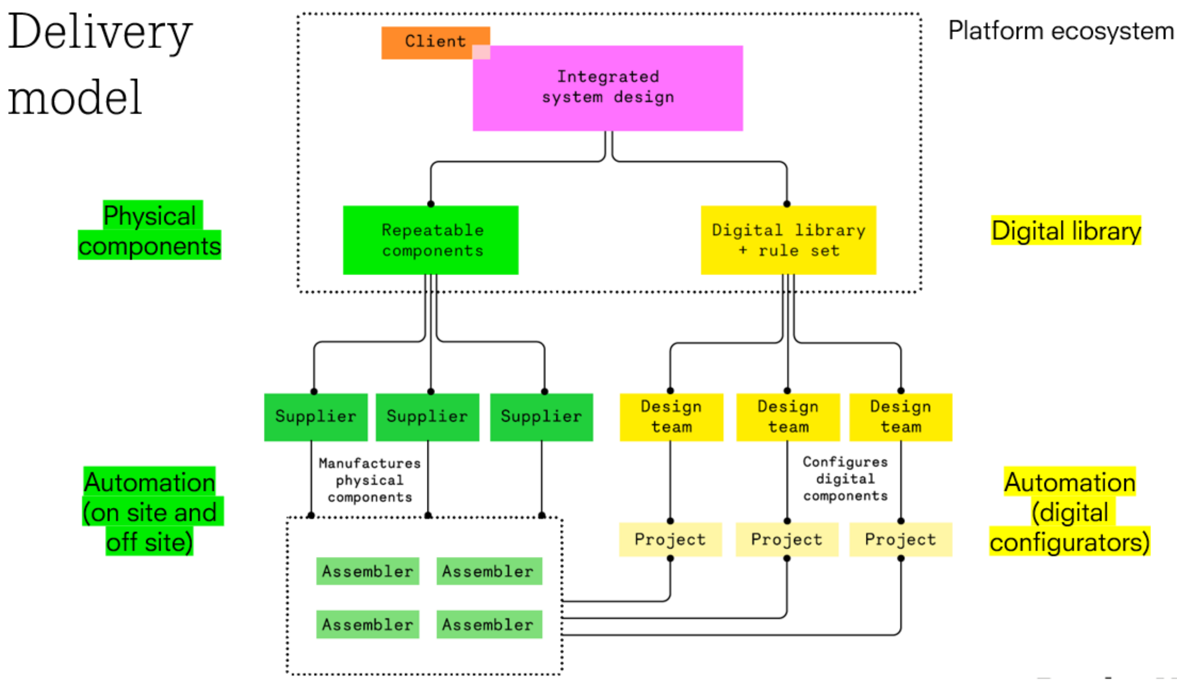
However, some construction issues CAN be solved by applying manufacturing principles. These Key barriers can be overcome to access the manufacturing approaches that are open to construction:

1. Repeatability. In traditional construction, every project is a prototype, every approach and design team are formed anew.

We cannot manufacture buildings, we need to identify a level of standardisation across asset components, which was Henry Ford’s transformative step to standardize the automotive industry. We need to decompose the object (the building) into components and sub-assemblies, which can then bring factory like levels of productivity onto site assembly.

2. Integration. As the complexity of construction began to increase, we began to disintegrate the knowledge base, the development of contracts sought to transfer risk. Silos between disciplines are created institutionally, and enforced contractually, promoting a narrow, short-term view of the overall project.

We need to form a new project management approach: a new central, co-ordinating role that drives efficiency right through the construction process, realizing the value in the integration of digital libraries and configurators, digital procurement, a disaggregated manufacturing base, factory-like logistics, and assembly using automation.



Overcoming these two barriers will unlock the following powerful manufacturing benefits:

1. Improve cost density – By focussing on and refining and optimizing repeatable components we can minimize effort required to turn raw material into the finished asset by handling and / or moving material: the fewest number of times; through the least amount of processes; with up skilled and / or highly productive people; using the least number of people overall

2. Continual improvement – constantly analysing data to:
    a. optimise the process – applying learnings directly and immediately from one project to another, transforming manufacturing into a self-optimising sector
    b. Locate activity where it is best suited, rather than mandating 'on site' or 'off site';
    c. remove waste, ref Taiichi Ohno's categorization of the seven major wastes typically found in mass production https://www.lean.org/lexicon-terms/seven-wastes/. Currently in the US over 40% of project capital is wasted on transactional cost (Source: CII Working Paper – Transactional Waste)

3. Piece count and flow-line based planning: moving away from traditional Gantt charts to ensure a consistent level of productivity

4. Integrated project management mindset- ensuring logistics are fully involved in planning, so Deliver materials + elements to site at the right time, in the right sequence, with the correct information

5. Automation – of design and manufacture of the components, on site robotics etc.

6. Stable pipeline - aggregating the requirements of multiple programmes (through the use of shared components) generates a consistent pipeline. This opens up construction to manufacturing type benefits, because a consistent pipeline means predictable demand. And when we can predict demand, we can plan. A more planned, proactive supply chain is more resilient; SMEs can be more involved, rather than single sourcing from one major player. It is also more distributed: keeping more investment in and ownership of social infrastructure in the target region.

How do we standardize? A Platforms approach to Industrialized Construction

'Platforms identify features of assets that could be shared and then harmonise those features. This approach provides the opportunity to create common 'kits of parts'.
Infrastructure and projects Authority, Transforming Infrastructure Performance: Roadmap to 2030

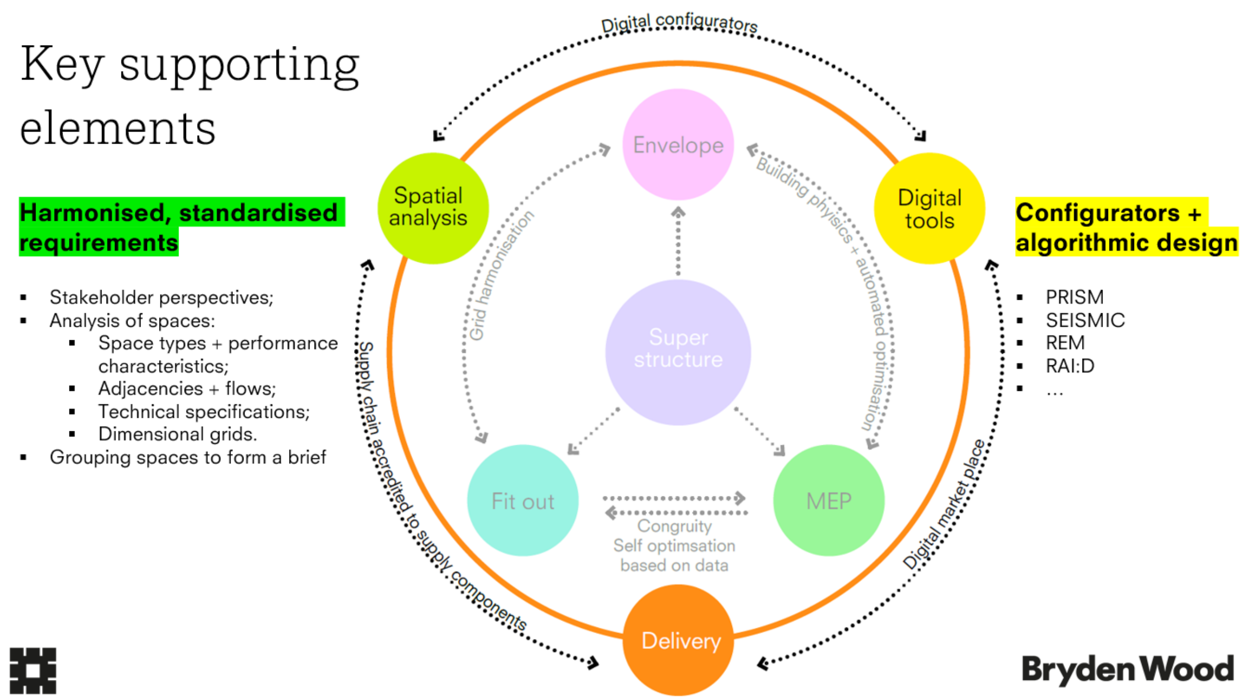
Harmonised cross-sector demand enables their manufacture in high volume, with configuration allowing delivery of multiple asset types across sectors (e.g., schools, apartments, healthcare facilities).

The major innovation comes from the superstructure; this unlocks the ability to standardize at scale, across sectors; in automotive terms, it's the car chassis which is sub millimeter perfect, so that the doors will fit exactly, the power train will fit etc.

In construction terms, MEP, façade and fit out are all easily incorporated into this, as the repeatable grid and common dimensions make these easier to design and install to within millimeter tolerance. MEP contractors are already prefabricating systems, and these can be designed to fit into the standardised carrier frame of the Platform superstructure.

This standardized platform approach begins with an analysis and understanding of what the common components are. We then develop configurators which house an open access data rich library combining the standardised requirements: standard space types, critical adjacencies and operational flows, spatial clusters for common configurations (e.g. standard teaching blocks), sets of rules regarding interfaces, technical requirements and standards e.g. tolerances, load, thermal performance and energy efficiency technical standards, rules around interoperability etc.

This mobilization of data helps users make best use of the wealth of data available. No longer overwhelming, it becomes easy to manage and utilize. This means it can feed into the circular economy; building a core set of information that can be re-utilized, creating feedback loops that can then inform the design of future assets. In this way, Platform design and how it integrates with the bespoke sections of assets, accesses the 'Continual improvement' manufacturing benefits from.



See more information here: https://www.brydenwood.com/how-we-do-its/platforms-pdfma/s91296/

Benefits of Platforms in practice

Landsec, the UK's largest commercial property development and investment company, has always been at the leading edge of tech-led design, investing in BIM and now in computational design within the business. So, they set out to achieve 5 key outcomes, to deliver buildings faster, better, more cost-effectively, more safely and more sustainably.

In 2019 Landsec & Bryden Wood partnered with product prototype and development company Easi Space to begin an R&D collaboration with UK Research and Innovation (UKRI, formerly Innovate UK) funding. This collaboration would take the traditional office design planned for the Sumner Street site in central London, now known as The Forge, and reconceive it with a tech enabled, platform 'kit of parts' approach; allowing the team to prove the value-add against the traditional design. Although this design was specific to the Forge project, it was to be repeatable for future Landsec projects (by capturing learning in digital tools) and for wider industry (by open sourcing all learnings via UKRI).

<u>Analyze, optimise and rationalize</u>
Bryden Wood took the initial site-specific design that had gained planning permission analyzed it along with several other Landsec schemes at varying stages of design, plus commercial sector guidance documents published by the British Council of Offices to identify key areas of potential rationalization and standardisation.

This led to a reduced number of floor-to-floor heights, and a highly repeatable kit of parts used for the 9m x 9m superstructure, which also benefited the design, manufacture and installation of the façade and MEP. Around 20% of the building was constructed traditionally, for example the end bays adjacent to the perimeter and the double height ground floor; combining the platform with elements of bespoke design meant Landsec would maximize the footprint, whilst remaining within the planning permission.

Cross sector application for Continual improvement
This project learnt directly from a previous public sector project with the UK Government's Ministry of Justice. The steel and concrete hybrid superstructure was based on the Ministry of Justice's mid-span 'Platform 2'; taking the same components, temporary works, method of manufacture and assembly, but configuring the components differently and adding one additional beam type to the 'kit' to boost the spanning capability from 4.2m x 8m bays for an MOJ building to the 9m x 9m office grid.

Initial Sustainability benefits were impressive
- 30% reduction in embodied carbon
- UK's first net zero commercial development – embodied and operational (certified by UK Green Building Council)
- NABERS UK 5 star rated

Productivity metrics and learnings from the project

Data was captured and analysed by a team from the University of Cambridge, led by Dr Danny Murgia, Research Associate in the Construction Sector.
The activities they were measuring included:

- Leading and lagging metrics
  - Time on-site (gross external area / day)
- Activity metrics
  - Installation rate of primary steels
  - Installation rate of ComFlor beams ♣ Installation rate of shutters
  - Concrete placement productivity

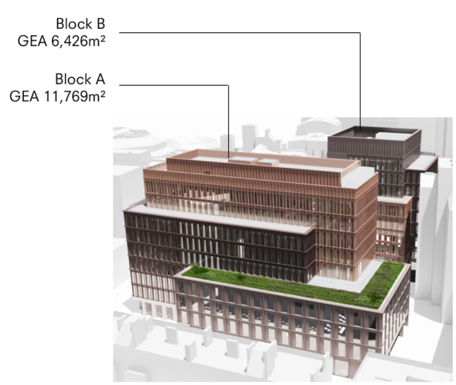
Block A was the biggest block, enabling the operatives to get into a flow of activity.

Average statistics
(Block A, gross external area 11,769m²)

Labour productivity - gross value add
- Total value of works = £7,738,020
- Labour = 2,934 operative days = 23,472 hours
- Average productivity = **£329.67 / operative hour**

Labour productivity - area
- Labour = 2,934 operative days = 23,472 hours
- Average productivity = **0.5m² / operative hour**

Time on site
- Working days = 243 working days
- Average install rate = **48m² / day**



These metrics are currently largely equal to a traditional construction approach. However, considering this is the first of its kind, the fact it achieved parity can go a long way to mitigating any perceived risk.

The critical learnings show potential for the approach to be much more consistent, efficient, and quicker:

Continual improvement is achievable both within a project and for the next project

- On the second floor, level 3, the team achieved their best productivity, so the learning curve was short, it only took one floor for the onsite team to improve their productivity dramatically.
- All the learning from this project will go directly into the next, so already we can be confident that the next build will be much quicker.
- We also know more about what to measure next time to continue to eliminate waste.

Labor productivity saw a huge improvement in productivity: £549 / operative hour compared to £329.7 generally

- This equates to a 40% reduction in time. In terms of area, the project achieved 0.88 m² / operative hour compared to 0.5 m² generally. This equates to a 76% increase in productivity per operative hour.

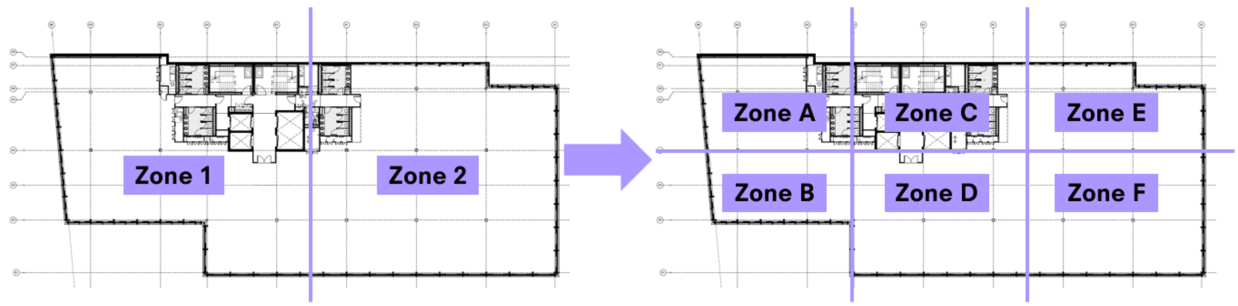
Activity planning and Logistics both need to change:

Across steel, Comflor and shuttering maximum installation was very high, but logistics couldn't meet demand or activities had been planned for a traditional construction site, which left a large number of days with no activity

- Steel per day: 12 pieces max, 0 pieces min (7 days), 7 pieces average
- Comflor per day: 10 pieces max, 0 pieces min (13 days) 2.43 pieces average. Maintaining an average rate of 5 / day, this would have been a 55% reduction in time vs traditional
- Shuttering per day: 18 pieces max, 0 pieces min (8 days), 7 pieces average. Maintaining an average rate of 9 / day, this would have been a 26% reduction in time
- Flow line analysis showed that inactive periods were 32% for primary steel and 23% for Comflor and shutters, showing the negative impact applying a traditional approach to logistics had on the project
- The team had to wait 140 days to begin installing the façade, as the planning was lifted from traditional build projects

Activity planning needs to change to be based on a proven piece flow count, rather than a traditional average assumed by project planners. Logistics needs to be based on a rephasing of on-site works.

Rephasing of works



- The above shows a theoretical re-zoning of a typical floorplate,
- This would reduce the inactive periods, to maximise the speed of installation while using the same performance of the teams (i.e. assuming the **same average install rate** for each activity)
- This would put an onus on logistics to ensure activities are fed with the right materials and equipment.

The Platform system allows projects to go quickly, however the activity has to be planned knowing this / with confidence in this. Project Management needs to move into a manufacturing mindset.

This project has provided critical benchmarks for future projects, which can now be planned, not with a traditional Gant chart, but using a piece count (the standard components, create standard processes, which mean standard activity, thus opening construction up to this manufacturing approach)

Consistency is more important than speed for now
If logistics was integrated and the operatives worked even at their average rate, not their quickest, they would still build the building 40% quicker vs traditional construction

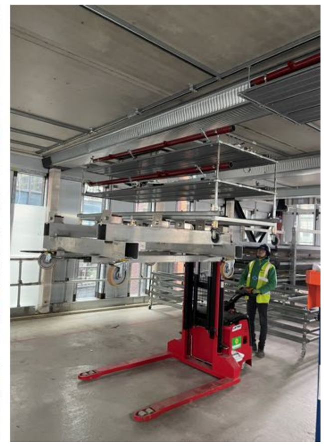
This building has proved the case for a platforms approach to industrialized construction
It provides real life, onsite statistics that demonstrate that we can be more productive and build faster and greener.

“With the benefit of the learnings from its first-time use, this is highly possible in future projects. When linked with a scalable logistics solution this could translate to a significant reduction in build time and cost.’ Cambridge University

<u>MEP</u>
The MEP challenge was to expose the services in a way that would keep the clear height and be aesthetically appealing, with a high quality and highly lettable finish. They achieved this by rationalizing the design down to a small number of repeatable units and components:
NG Bailey, champions of the use of offsite manufacturing techniques since the 1990s, were appointed to manufacture and install these MEP systems. Production took place at their specialist Offsite Manufacture facility in Bradford where their innovative manufacturing and assembly processes increased speed, sustainability, safety and productivity:

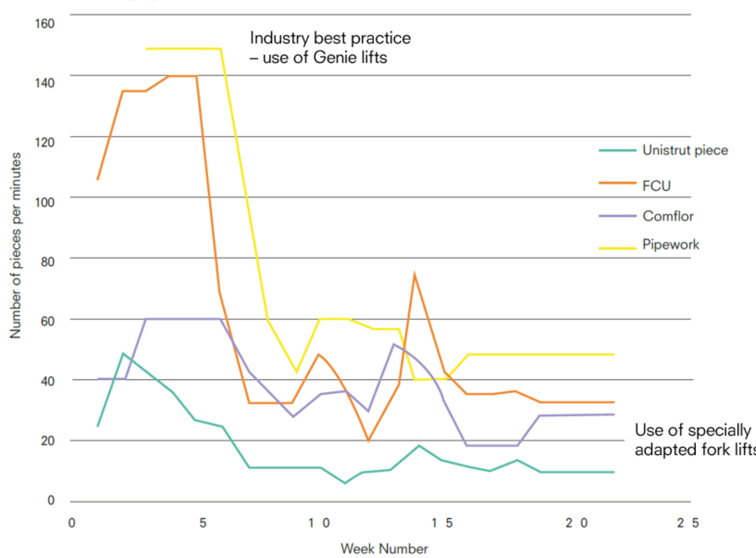
- Pre jigged benches were set up so that the adapter frame could be fit out incredibly quickly.
- The frame was then wheeled across to the pallet, where 6 could be stacked together on a special stillage.
- This would be loaded into the transport and delivered to site
- On site, the use of an adapted forklift (instead of Genie lifts) meant that the stack could be transported across the floor plate, installing the top bay in the stack, moving on to install the second one and so on, with the only waste being the upstands between the stacks.





Weekly module install times

- Install times are shown in the graph on the right
- The dramatic reduction coincides with the introduction of the adapted forklifts in weeks 5 – 6
- **Install times were reduced by 66% - 90%**
- NG Bailey estimate the prefabricated nature of the MEP has resulted in a **reduction of 30,000 hours** of site labour

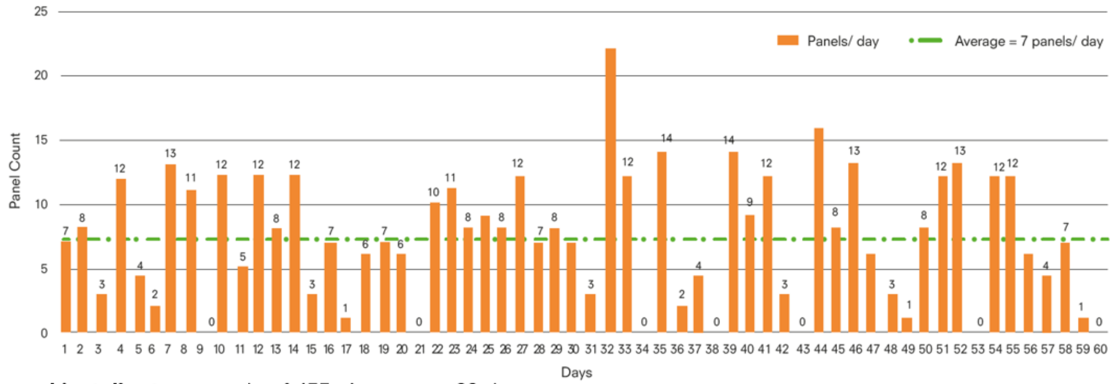


<u>Façade</u>

Landsec were so confident in the accuracy and logic of the façade design, that they were able to award separate contracts for its manufacture and installation.

Safety handrails were designed into the superstructure – with the ability to leave them there until the façade was in position. This both reduced danger to operatives on site and helped with the ease of installation of the façade. At peak productivity one panel was installed every seven and a half minutes.

Daily variability



Façade panel install rate – sample of 435 pieces over 60 days

- Maximum = 22 panels / day (with 10 or more on 4 days)
- Minimum = 0 pieces / day (on 7 days)
- Average = 7 panels / day
- Average rate was exceeded on 34 of the 53 days when panels were installed
- 10 panels / day or more were installed on 20 days
- If a rate of 12 panels / day were achieved, cladding would gave taken 37 days, a **nearly 40% reduction in programme**

<u>Achievable improvements</u>

Without increasing the rates already achieved, the following targets are viable:

Superstructure
Achieving consistency (reducing variability) shows a **potential programme reduction of 25% - 55%**

Resequencing the floorplate to minimize periods of inactivity could result in a **programme reduction of 43%**
Maintaining maximum productivity rate could **reduce operative hours by 40%**

Façade
Without increasing current install rates, achieving consistency (reducing variability) shows a **potential programme reduction of 40%**

MEP
Existing rates show **programme improvements of 66% - 90%** compared to industry best practice.

Using the platforms approach to standardize design and construction we can be more like manufacturing

- We can improve cost density
- We can benefit from Continual improvement
- We can deploy piece count and flow line planning approaches rather than traditional Gant charts
- We can develop a new integrated project management mindset and role
- We can automate across both design and manufacture of components
- We can achieve a stable pipeline and predictable demand

And these will, in turn, open up construction to further benefits:
- Facilitating further innovation in automation in manufacture and assembly processes.
- Creating a more formal programme of training in key competencies for operatives.
- Creating a marketplace for a more sophisticated approach to logistics (and justifying e.g. regional logistics / consolidation centres).