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John Sisk & Son Ltd. ("Sisk") is an innovative international engineering and construction company employing over 1,300 people across its operations in Ireland, the UK, and Europe. Sisk has the track record, scale, and capacity to successfully undertake large, complex, multi-disciplinary programmes, and we are recognised by our global customers as world leaders in safe delivery. Operating since 1859, Sisk is a progressive business with long-term vision and is ranked as Ireland's No.1 provider of construction services.

Sisk's strategy is to create value for customers, partners, and people through technical knowledge, ability, and experience:

- We collaborate with our customers and supply chain to provide technical and delivery solutions in an open and can-do way to meet aligned objectives.
- We offer a full range of solutions where safety, innovation, quality, efficiency, and value are integral to everything we do.
- We deliver projects and programmes in key sectors such as Data and Technology, Pharmaceutical and Life Sciences, Infrastructure, Transportation, Healthcare, Commercial, Residential, Retail, Industrial, Leisure, Education, Water, and Energy.

Author

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Overview & Background to the Lean Initiative

The Project Team was tasked with constructing two blocks of student accommodation (145 bedrooms) on a particularly confined site in a residential area of Cork City. There were a number of key challenges, including:

- The building footprint covered the entire site to within 1m of the site boundaries, except for an open corridor between the two blocks.
- Working hours were limited by a 6pm finish from Monday to Friday, with no weekend work allowed.
- Project duration was only 15 months.

The structural frame was in-situ concrete. Typically this work requires a generous lay-down area and routinely ends up over schedule and over budget owing to the labour intensive and linear nature of the work, as well as susceptibility to weather and logistics issues. Poor productivity rapidly escalates when labour, deliveries, and cycle times are not all perfectly aligned.

The remainder of the project comprised the building envelope, external works, and the fitout of 145 student bedrooms and common areas. This element in particular would benefit from Lean techniques developed by Sisk on similar projects which involve significant repetition, getting the construction detail absolutely right, adjusting details and sequence such that each trade only visits each room once, and absolute insistence on defect-free handoffs from trade to trade.

Figure 1. Drone Footage of Top-Out Pour on Reinforced Concrete Frame

It was clear that delivering a "Lean Concrete Frame" was key to a successful project. The value of the concrete frame was 21% of the total project value, the duration was 7 months (of the overall 15), and by its nature the concrete works were entirely on the project critical path. We needed efficient delivery with high levels of productivity and with the target to deliver on time, within budget, and with zero compromise on quality or safety.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

We focused on the following seven key Lean Concepts:

i. Training and creating awareness of Lean principles.
ii. Collaboration between all parties (designer, main contractor, and concrete frame contractor).
iii. Understanding the customer requirements.
iv. Map the value stream and focus on the detail to improve flow.
v. Maximise efficiency of plant, equipment, labour.
vi. Productivity of labour, measure and monitor output.
vii. Direct observation studies to aid productivity.

Training and awareness of Lean principles

The project team were supported from pre-commencement stage by Sisk in-house Lean specialists and through external training and mentoring delivered as part of our Lean Transform programme. All of the Sisk project team were trained as Lean Yellow Belts, with workshops between Sisk, designers, and contractors helping to secure support for the Lean execution approach.

Collaboration between all parties

We selected our concrete frame partner not only on the basis of cost, but on their previous experience. They had worked with us previously, understood our open project approach, and were committed to investing and contributing to a collaborative approach. The design team were also keen to engage.

Understanding the customer requirements

For the purposes of the concrete frame, we considered the design team and our concrete frame contractor as our customers. The structural designers needed a building that would be strong enough to fulfil its structural functions, as well as being structurally sound in all temporary conditions (mid-construction). The architectural designers needed structural detailing that would allow them to support the external facade for example. The mechanical-electrical designers needed to allow for openings in the structure for the passage of services. Our frame contractor needed a design that facilitated efficient construction, needed space onsite to lay down shutters and needed to limit any unnecessary use of materials, plant, or labour. Sisk itself was the customer of both the design team and the frame contractor, and we needed a design that maximised our efficiency and a rapid construction within a budget.

Map the value stream and focus on the detail to improve flow

The building had been designed to suit the final architectural and structural requirements, for example, four stair towers were designed to be constructed floor-by-floor in the same timeframe as the columns and slabs adjacent, and the elevated floor-slabs included a downstand beam on the perimeter of each floor.

The collaborative process concluded with a revised design, a standardised layout to suit the formwork systems of our frame contractor, and a revised stair tower design that facilitated early construction of the stairs to full height. This was a win-win solution – not only did the frame contractor now have space to lay down their bulky wall shutters, but they could also significantly shorten the overall hire period for these wall shutters and remove cranes from site at an earlier date. The designers also had more time to design the main floorplates by releasing the stair cores early.

Working together, we redesigned the internal leaf of the facade from blockwork to a lightweight steel frame system. This resulted in the removal of a concrete downstand to the perimeter of the reinforced concrete frame which provided a flat slab and soffit for the formwork system. We standardised the wall and column sizing to ensure that the formwork system was interchangeable between pours and did not have to be split and rebuilt following each concrete pour.

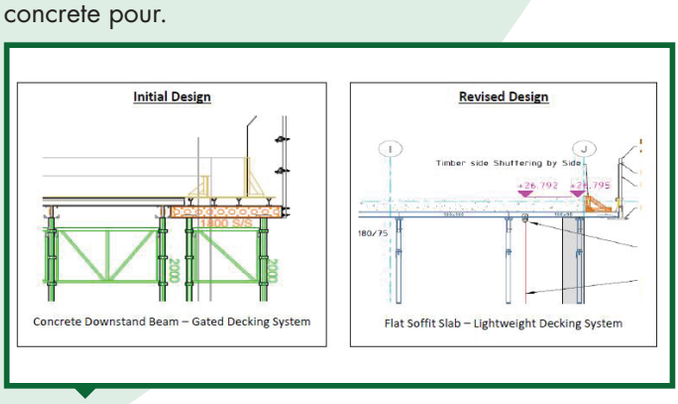

Figure 2. Downstand Decking System & Flat Slab Decking System

Maximise efficiency of plant, equipment, labour

The construction of an in-situ concrete frame can be broken down into a four-step process: install formwork; install reinforcing steel; pour concrete; and strike shutters. The plant and material resources are different for each step, and each step typically involves separate personnel. Planning the work to ensure continuity of efficient work fronts for everyone is difficult and depends on developing a cycle time and rhythm to the works.

To support continuity and to improve cycle times, our team changed the concrete mix design to secure faster curing times for finishing concrete – this allowed us to power-float slabs within the planning hours (18:00 off-site) whilst also ensuring earlier formwork striking times. Reinforcement design was enhanced – the normal commercial priority is to reduce the reinforcement content to the lowest possible tonnage and our Lean approach resulted in us increasing reinforcing steel content for two reasons, namely we standardised bar lengths for ease of fixing and we added steel to facilitate early shutter removal, thus enhancing cycle times.

Productivity of labour, measure and monitor output

We mapped out the targeted cycle times for each element of work and fine-tuned the resource requirements for each step. This allowed us to "flex" the resources to suit the workload. Output for each crew was visually marked and measured on colour-coded layout drawings daily, and this provided the team with certainty on cycle performance and also identified particular details where excessive labour was being absorbed. We reviewed these areas and fine-tuned details for the next cycle. Measuring the tonnage output of reinforcement allowed us to identify periods of activity where we could reduce and increase resources whilst also understanding which elements of the reinforcement were more onerous than others, like, for example, with shear links where we changed from a traditional shear link to a shear rail.

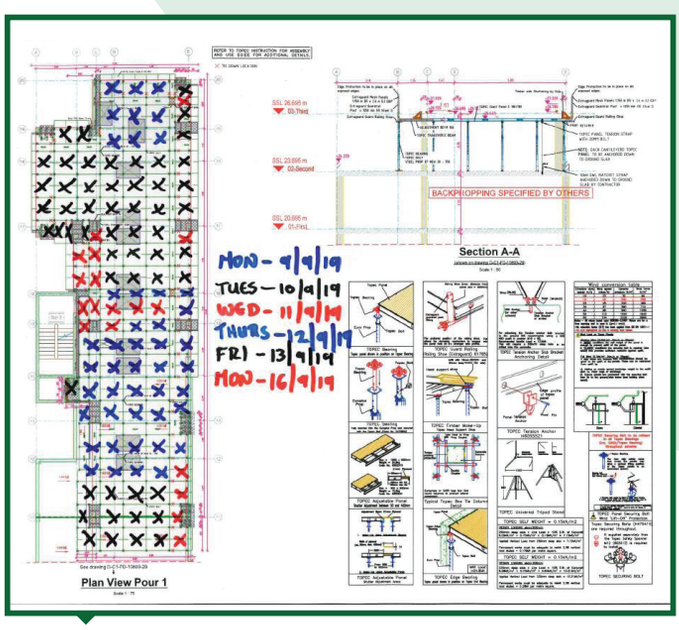

Figure 3. Example of Decking Installation Mark-ups for Progress Tracking

Direct observation studies to aid productivity

We engaged with specialist Lean consultants to undertake Direct Observation studies. We already understood the actual output rates per crew per day, and had identified particular construction details which were absorbing too much time. Direct Observation would provide us with independent data on where and to what extent waste was occurring within key activities, in particular, waiting, excessive transport, and movement.

Experienced construction professionals and supervisors understand the reality of moving materials on-site, the challenges of "crew sizing", and the inevitable intermittent downtime involved during concrete pours, for example. Sometimes we can "know too much" and thus in this project we engaged with a specialist Lean Consultant whose experience was in manufacturing and they would analyse our processes against a manufacturing type standard.

Prior to commencing the studies, we engaged with the craft operatives to explain the process and the purpose of the exercises, and everyone was happy to be involved. The following work activities were then observed and recorded on five days over a five week period, with feedback given to the site team after each visit and in advance of an overall report including:

- Erection of formwork decking.
- Installation of reinforcement.
- Pouring of concrete.

Erection of decking

This was characterised by significant movement and waiting, primarily associated with sourcing ancillary components, like, for example, fixings and ratchet straps. Crews were starting work with all bulk materials available in the correct location and with boxes or stillages of ancillaries to hand, but they subsequently lost a lot of time gathering the remaining components and bringing them to the location needed. The solution was to analyse the propping drawings in advance and organise the correct quantity of all ancillary items and deliver to the work area mechanically with the bulk materials.

Installation of reinforcement

Significant time was being lost sorting out the different bar sizes and shapes required for each area. The process involved checking the steel drawings to identify the bars needed, checking the steel schedule to identify the bar numbers involved, checking the bar tag to identify the correct bundle, and tape-checking the bar itself to confirm it was correct – all before taking the correct numbers of bars to the fixing location. The obvious solution was to re-design the steel so that there were fewer types of bars needed for each pour.

Pouring concrete

Extensive time is generally lost in part because of the timing of trucks – that is, a full crew waiting for the next concrete truck to arrive. Sometimes this is unavoidable or at least beyond the control of the site team – the nature of concrete is that it must be "just in time" and queues at the batching plant or traffic can delay trucks. However, the direct observation record showed that a five-person crew could (notionally at least) be reduced to four or possibly three. In particular, it was noted that the concrete pump operator was 60% waiting/not working.

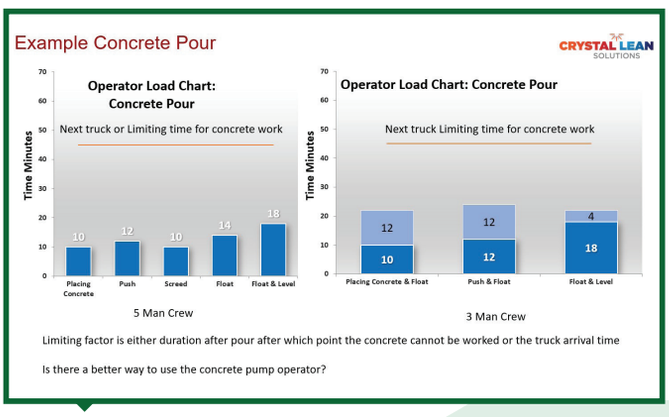

Figure 4. Example of Concrete Pour Breakdown

The summary report on the Direct Observation exercise identified that up to 48% of the time spent on certain elements of the works were "waste", primarily waiting, either for deliveries or waiting for materials from within site.

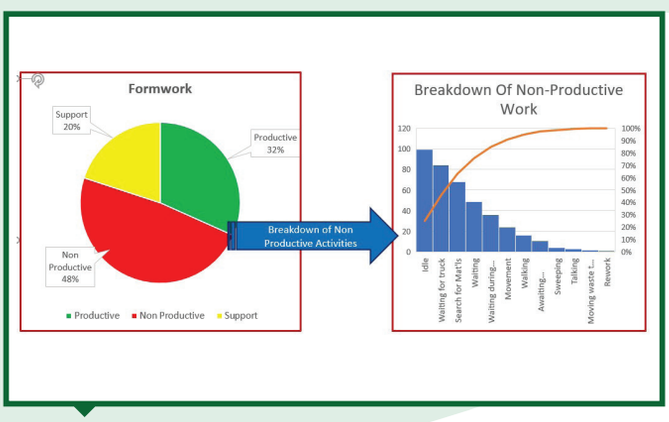

Figure 5. Direct Observation Summary Report Extract

Lean Initiative Improvements & Impact

The "Lean Project" approach had both a direct and measurable impact, but perhaps more significant is our enhanced awareness of the extent of waste on our projects. The nature and dynamics of a construction project are different to a manufacturing environment, but the cold theoretical assessment of wasted effort (up to 48%) certainly gave the team a number of opportunities for immediate improvement, as well as pointing to longer-term potential. Clearly the full 48% can never be eliminated, but we made improvements:

- The concrete frame was completed in 6 months, reflecting a one-month improvement on schedule.
- The concrete frame contractor and Sisk had a very satisfactory commercial outcome from the concrete frame package which represented 21% of the overall project value.
- The works were delivered to a high quality and with out any safety incidents.
- As the first significant package on the project, the success and the manner of execution of the concrete package set the tone for the remainder of the project.

There were a number of notable wins:

i. Revising the design and construction sequence to construct the stair cores prior to the construction of the main frame had a double benefit. It gave the design team additional time to design the under-slab drainage whilst at the same time allowing significant flexibility to construction. Four work-fronts were open simultaneously with adequate laydown area available. Mobile cranes were required to construct the stair-cores, whereas the remainder of the structure could be constructed with more cost-efficient teleporters. Front-ending the stair-core construction allowed us to off-hire the mobile cranes early in the project, with resultant shared savings.

ii. Rationalising the frame design and eliminating the downstand beam allowed us to use a lightweight system which could be erected in a bottom-up sequence so that the decking system could be erected whilst standing on the slab. This not only had a safety benefit, but also cost and schedule benefits.

iii. Planning out the cycle times in detail in advance highlighted both problems and opportunities; for example, altering the concrete mix design to a higher strength concrete with a super plasticiser. For a standard concrete slab pour of 80m3, we started pouring at 8am, had the concrete installed by 12 noon, and were finished power floating by 5pm.

We then utilised the final hour of the day from 5pm to 6pm to pour column kickers which gained us a day in our reinforced concrete frame cycle. The higher strength concrete also ensured we were at our necessary 30N concrete strength after 3 days, enabling the stripping of the formwork decking system with associated back propping installed.

iv. Measuring outputs per gang proved to be a very simple task and gave us close control both of schedule and cost. The frame contractor field supervision could see immediately that the efforts were directed at boosting their productivity, not "catching them out", and they bought-in readily.

v. Direct observation studies provided simple approaches to pre-commencement activities to focus the tasks on maximising outputs for operatives once the task had commenced. The pre-task organisation brought immediate buy-in from the operatives on the ground as it removed their frustration in organisational aspects of their tasks and allowed them to focus on the productive elements.

vi.The formwork operatives on site were motivated, cooperative, and genuinely interested in the Lean techniques implemented on site. They were able to identify our interest in their performance and how we actively sought their feedback on the measures to find out what was working and how we could make alterations to further align the Lean initiatives.

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