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Digital engineering and project controls in the construction industry

Introduction

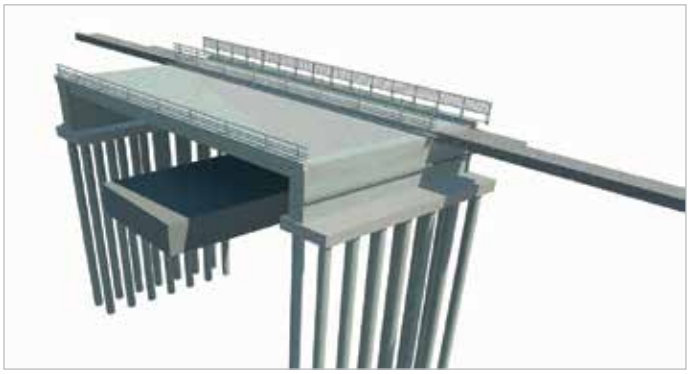
Laing O'Rourke is committed to leading the modernisation of the construction industry and is currently undertaking a massive change management programme as the company embraces what they call a "digital engineering" (DE) approach to project delivery of innovative solutions for its clients.

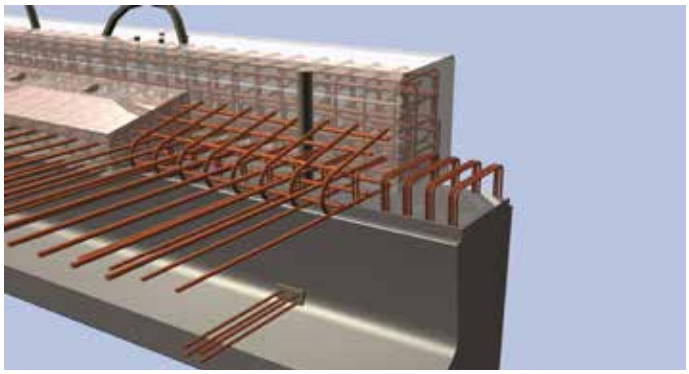
The digital engineering process will deliver an integrated set of geometric models, data and documentation that builds over the life of a project, to capture all knowledge related to that built asset. It's clear that this offers many benefits, including an increased predictability of project outcomes in terms of safety, design, cost, schedule and quality.

Motivation

Following the establishment in 2012 of the Engineering Excellence Group, an in-house group of engineering experts driving technology transfer and the development of innovative solutions, Laing O'Rourke adopted a business model centred around the Design for Manufacture and Assembly (DfMA) approach, employing offsite manufacturing for construction.

A good example of this is the A453 project in Nottinghamshire, where a bridge abutment and beams were installed in three working days, compared to the traditional in-situ approach which would have taken weeks of site time.





(Top) A453 structure S4, with precast beams in place and deck reinforcement commenced.(Middle) Digital design model at 'construction issue' status.(Bottom) Composite edge beam reinforcement details from Explore Manufacturing

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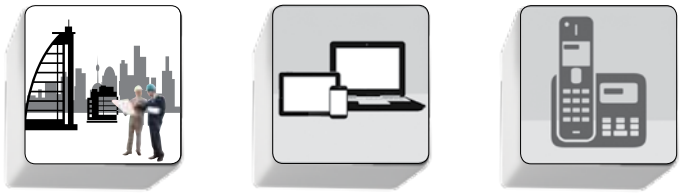

Converting traditional construction processes into a modular and controlled on-site assembly of components manufactured off-site was a key challenge. This was solved through effective management of project information, using digital models to integrate design information, programme schedules, progress status and quality assurance records, to make them visible to all across the organisation.

Augmented reality allows designers and clients alike to get a much clearer understanding of how a structure will look and perform, compared to conventional 2D drawings. When taken to the site it allows model data to be overlaid on the image being captured on the mobile device. When used with the project controls tools developed this technology allows quick visual progress checks.

Development

Using tablet-based devices and similar technologies onsite, allowed the company to view and interrogate the status of each component from its initial design to manufacture, installation and onto final acceptance. Importantly, integrated information enables generation of automated project reports and charts.

With well-defined processes in place, warnings and exception reports can be automatically generated, helping managers to identify any issues upfront and avoid impacting upon the delivery programme.

This advanced approach to project controls is a key enabler for a just-in-time strategy, which is increasingly required on significant projects in dense urban areas. For example, the footprint of the Leadenhall Building covered the entire construction site, leaving no room whatsoever for the storage of materials or components, so logistics management and just-in-time delivery were critical.

While DfMA has principally been applied to large structural elements, it is now starting to be used for mechanical, electrical and plumbing (MEP) components, including such 'product families' as modular plantrooms. These plantrooms are configured using parametric digital modelling, where pipes are automatically resized in response to their required flow and manufactured using the latest pipe-bending technology, designed to minimise potentially vulnerable pipe joints.

With all product components optimised and tested prior to manufacture, the risks traditionally associated with building systems commissioning can be significantly reduced.

Results

Crossrail Custom House station is a classic example of applying a solely digital approach to project controls.

Here, digital engineering solutions helped site teams to better manage project planning, sequencing, re-planning and delivery. This allowed for greater certainty of cost at an earlier stage in a project, and coupled with DfMA to provide significant improvements in logistics and materials scheduling.

Employing digital engineering for Crossrail Custom House station has enabled detailed data to be fed directly from the model to Laing O'Rourke's Explore manufacturing facility. This has enabled project controls to be monitored, tracked and optimised at a level that has enabled the project managers to be pro-active rather than reactive.

Critically, where off-the shelf CAD tools didn't meet with company requirements, the business invested in the development of in-house software tools and plug-ins. This ensured that models could link data from various external sources, visualise using bespoke colour filters and maintain dynamic links between model objects and associated data. Visualising the construction sequence with colour-coded component status proved to be an extremely useful tool for communicating progress

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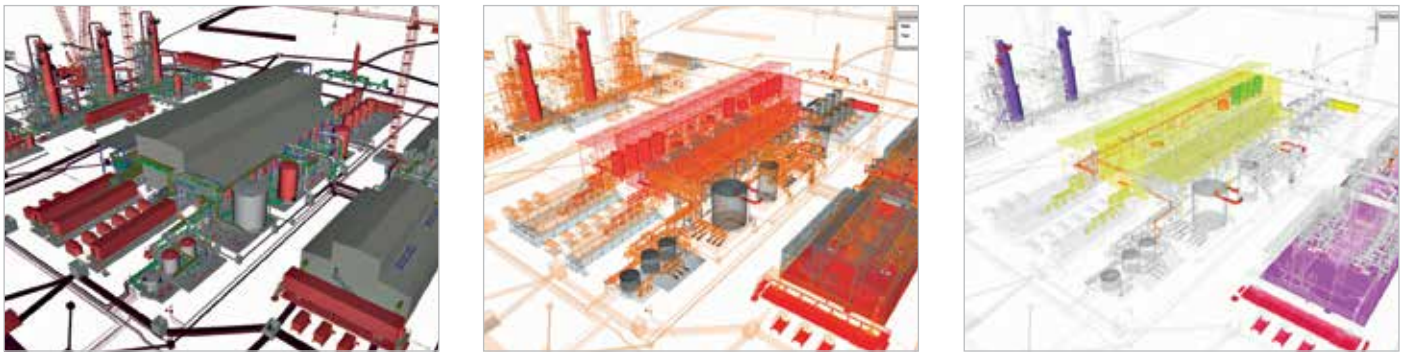


(Left) digital models of the Northern Water Treatment Plant (Australia) with visual identification of: (middle) critical path for the project and (right) total float gradient for activities in the programme.

to stakeholders, allowing for a clear, dynamic, visual identification of a critical project path and upcoming work through the life of the project.

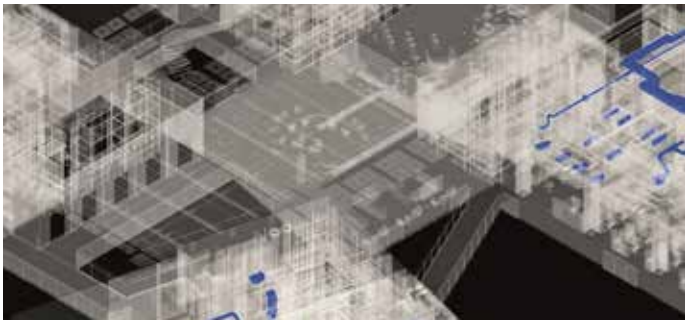
Next Steps

In the future, digital engineering will impact further on the world of MEP, where ever-higher rigour is required.

The use of product lifecycle management (PLM) tools integrated with digital models is critical to meeting the rigorous requirements of design assurance: buildability and maintainability. In construction, the maintainability problem is commonly overlooked and relies on an asset management (AM) capability, as the industry is not incentivised to add value for handing on from construction to operation.

PLM technologies can enable a more intelligent AM provision, with users ranging from the architect and design engineer to those responsible for aftercare, allowing for condition-based monitoring regime across an asset's entire lifecycle instead of having to follow a regime of planned preventative maintenance.

This approach is fundamental to the UK Government's desire for BIM and soft-landings in the construction industry, changing the approach from design-and-build followed by handover-to-operate, to a more integrated approach as part of new procurement contracts (BIM Level 2 is mandated by the UK Government for public-sector projects from 2016).



However, technology is only one aspect of the challenge; more connected thinking and barrier removal is required if the industry is to truly leverage the advantages that digital engineering brings.

There are many in the construction sector yet to begin their digital engineering journey, but as Laing O'Rourke's Chairman, Ray O'Rourke notes, "*Tomorrow's engineer will be defined by their ability to integrate innovative engineering approaches, digital technologies and rich data.*"

Dr Graham Herries FIET is Functional Director of Systems Integration within the Engineering Excellence Group at Laing O'Rourke. He joined from Rolls-Royce where he was Head of the Software Centre of Excellence. Graham's focus is on delivering greater value from both IT and automation systems through enabling greater integration between platforms and tools along with the optimisation of processes.

Laing O'Rourke is a privately owned, internationally focussed engineering enterprise, with over 15,000 employees globally, and with capabilities comprising the full range of engineering, construction and asset management services.

More information on Laing O'Rourke's approach to Digitial Engineering is available via: **http://www.laingorourke.com/engineering-the-future/digital-engineering/eej**