UNIVERSITY OF CAMBRIDGE
Department of Engineering

CONSTRUCTION ENGINEERING MASTERS DISSERTATION ABSTRACT

Knowledge based construction: Creating a scalable and flexible production model

In 2013 the UK Government and UK Construction Industry developed a guide to "help the sector grow and have the aspiration, confidence and drive to compete in the global (economic) race". It is called the "Construction 2025" strategy (Sir David Higgins Government & Industry 2013). It challenges the sector to cut construction cost by 33%, reduce project delivery durations by 50%, minimise the emission of greenhouse gas by half and diminish the gap between total imports and exports by 50%. It acknowledges that leading the industry towards these targets will require profound changes to the way projects are being delivered. This will be challenging for numerous reasons, amongst them the fact that the industry is struggling to attract young talent who will progress the trade into a digitalised and sustainable future.

Similar to the way the building sector is producing housing units today, the automotive industry was producing vehicles to order in the late 19th century. Cars were engineered and designed to client specific requirements and built by hand. Henry Ford identified that standardisation and advanced, serial production would move the industry into high volume mass manufacturing with increased profit margins. Ford changed the automotive not only by implementing a standardised design but by challenging established delivery models. He ensured that Ford car design was aligned with manufacturing capabilities, thus allowing for mass production. Initial manufacturing processes have continuously been optimised and streamlined since then. While the automotive being one of the most advanced manufacturing industries, it has been noted that the car sector is struggling to further evolve their delivery model towards fully flexible "Catalogue Based Mass Customisation (MC)".

Design for construction has not evolved significantly over time. Every building project is considered a prototype, developed and engineered to order, with limited opportunity to incorporate standardised components that allow for improvements such as the reduction of site construction durations. In an attempt to increase offsite manufactured construction, some companies have been exploring new design and delivery techniques over the last decade. Inspired by the automotive industry, rule based modelling and automated manufacturing processes are finding their way into construction to improve productivity, reduce project delivery cost and programme durations. This delivery process for component based manufacture in construction is called: Design for Manufacture and Assembly (DfMA). It has been demonstrated that DfMA has improved delivery speed by 30% and reduced on site labour requirements by 60%. This success has resulted in a greater demand for Mass Customised DfMA project delivery. However increasing the number of DfMA based delivered projects to achieve the Construction 2025 targets is challenging: a study of post-production storage durations has found that DfMA results in a misalignment between manufacturing and site installation. Manufacturing has been driven by optimising production sequencing whilst construction teams have been seeking to optimise installation sequencing with minimal component storage on site.

Some industries adjust their production sequencing to suit customer call off requirements. A storage data analysis of a concrete component manufacturing plant and a cost of capital analysis for a modular housing product identified that a DfMA delivery model was not sufficiently adaptable to allow for a high volume Mass Customised manufacture delivery approach, primarily because of high post-production inventory holding costs. Therefore a new delivery model for "Automated Design and Manufacture for Mass Customised Products" (ADAM) was developed by the author. This delivery model utilises project specific information streams – produced by project monitoring tools – to align production with site progress. Further benefits of these project data streams were explored. This study identified that ADAM would lead to: benchmark, inform and (in future) design new projects, Leading to a 'Knowledge Based Construction Industry'. In order to illustrate the benefits of ADAM in construction, a Mass Customised (robotically built) modular housing system has been used as a case study. This suggested that ADAM is the key to achieving the Construction 2025 strategy..

Carsten Mundle October 2016