Robot wars

23 October 2017

Dale Sinclair looks at emerging technology that could redefine the way buildings are designed and constructed

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With the roll-out of Level 2 building information modelling (BIM), the way information is supplied for projects is already changing. Although the construction process is starting to be transformed, there is still much to do, and everyone involved in the industry needs to understand the substantial changes ahead as new ideas are adopted and mature.

While this article concentrates on changes likely to occur in construction in the next few years, professionals need to remember that the design process will also be radically redefined. Many treat design and construction separately; however, neither exists in isolation, and it is unlikely that the core targets of the UK government?s Construction 2025 strategy ? a 50% reduction in the time taken and greenhouse gases emitted by projects, alongside 33% lower costs ? will be achieved unless there is significant interaction between them. New design and construction processes will require digital tools and technologies beyond those currently perceived as BIM.

Innovation v inertia

Business models underpinning the construction industry make innovation difficult. Design teams have the skills to innovate, but lack funding. Contractors have a greater need for new approaches, but their drivers and demands are different from those of designers.

Embedded cultural structures and the regulatory environment make shifting to new methods of construction difficult. Transformation is also tricky when the industry lacks a culture of research and development, and the funding for it. It is for this reason that the technologies we still use to construct the majority of buildings today were developed a century ago: the steel frame for example.

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To complicate matters, the places we construct buildings present challenges other than logistics. There is a substantial difference between the environments where building materials and products are tested and the mud and grime of a typical construction site. The industry needs products that can accommodate the worst-case scenarios on site ? for example, when they are not installed in accordance with manufacturer?s recommendations or the design team?s information. Moving from construction on site to prefabrication in factories offers more than safer, cheaper, greener and faster ways of making a building; it opens the door to new materials and different manufacturing processes. Put simply, the construction process can be transformed.

Waves of transformation

The challenges of bringing new materials and manufacturing processes to market suggest there will be two waves of innovation and disruption in construction. The first wave will include technologies that transform the construction and assembly of buildings using robotics and other innovations, without the need to consider issues of a building?s performance or longevity.

In the second wave of innovation, new materials will transform buildings? performance; for example, a generation of green and energy-producing facades will adapt buildings to their surroundings. However, given recent events in west London, it is likely that more rigorous testing of new facade materials will be required. Therefore the use of robotics to assemble items on site is likely to be taken up much faster than the 3D printing of building components.

Off-site manufacturing is one modern method of construction that is being rolled out, and was widely covered in the Farmer Review, Modernise or die . Farmer underlined the importance of modular approaches as part of a construction economy that shifts effort and emphasis away from the building site and into the factory; yet this form of construction is not new. What has changed is that there is renewed attention on the way modular construction can be redefined to ensure high-quality outcomes. The challenges involved in increasing uptake of these methods are substantial.

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Modular construction will improve productivity, though it still relies on human labour, albeit less skilled. Output is unlikely to improve further until robotics are used at scale. But robotics are already improving health and safety on site: for example, enabling demolition works to be undertaken by operatives at a distance from the workface, or to drill holes in concrete soffits so construction workers need not use mobile platforms. In the former example, the robot is manoeuvred using coordinates that have been input in an office; in the latter, the robotic device is controlled remotely by a human worker.

The roll-out of robotics arouses strong emotions associated with the potential loss of jobs, but the reality is that, in many instances, value is added by drawing on the strengths of both. Car manufacturing facilities have been using semi-automated processes for some time, with robots employed where possible and humans undertaking the tasks that are currently more difficult for technology to perform.

Modular v modern methods?

Increasing the uptake of robotics requires the development of appropriate use cases as well as considering who will own the robots themselves: specialist subcontractors, product manufacturers, contractors or plant hire companies? Who will provide the coding that makes them work efficiently and the exercises essential to determine how they might assemble items?

Modular factories still rely on human staff to construct their units, yet many industries are already using factories where robotic devices manufacture products with minimal human intervention. This makes round-the-clock manufacturing feasible, with the potential to improve productivity radically. Most modular factories are a long way from this level of innovation, however, and greater investment is required if robotic arms mounted on gantry cranes are to become commonplace.

Although modular approaches are ideal for most residential projects, they are less suited to larger projects such as offices, airports or railway stations. On these projects, design for manufacture and assembly (DfMA) offers a way forward. The DfMA overlay to the RIBA Plan of Work as commissioned by the Offsite School sets out some of the topics that need to be considered.

One core issue is that modern methods of construction (MMC) are not something to be considered at stage 4; many technologies in fact need to be selected and incorporated into the concept design proposals at stage 2. Failing to do so can result in traditional construction methodologies remaining the default for the concept design.

A central challenge in the future will therefore be determining which technologies will be used in the construction process. More importantly, who determines these technologies if they need to do so at stage 2? Many current procurement routes are not geared for this approach and would need the earlier involvement of the contractor in these decision-making processes.

Is it fair for the design team to determine the manufacturing and construction technologies to be used on a project?

The roll-out of MMC presents a similar conundrum. Is it fair for the design team to determine the manufacturing and construction technologies to be used on a project? Or will new procurement processes emerge?

Business models that are more product- than project-oriented are already emerging in housing construction, but this points to the significant gap in the market: large subassemblies cannot be purchased as products but are instead developed as bespoke project items.

Extra factors

Other considerations will also influence construction. For example, circular economy initiatives dictate greater consideration being given to the way that buildings are disassembled, as well as how they are assembled, and to renting products such as lighting that are returned to their makers at the end of their life.

The holy grail of new construction technologies is additive manufacturing, or 3D printing as it is frequently known. This offers endless opportunities from a design and construction perspective. Current use cases such as the houses printed by Winsun in Shanghai, China, point to a solution to the world?s housing problem; transforming one or two prototypes into large-scale responses is a different proposition, however.

Formula 1 and the aerospace industry are both already using 3D printing. F1 teams are able to make subtle adjustments to a car part based on data collected from the vehicle following a race, which allows redesign, real-time research and development, wind tunnel testing and printing of a new aerofoil between one race and the next.

The army and navy have also shown an interest in 3D printing to assist with logistics: maintaining a stock of parts for tanks or ships close to their point of use is challenging, but 3D printing enables replacements for broken parts to be printed on the spot and equipment to be remobilised faster and more efficiently.

New metallic mixes for aero engines are also reducing the normal manufacturing waste associated with producing complex shapes by subtractive manufacturing. These have been comprehensively tested, and the methodologies for calibrating 3D printing heads and materials testing have developed over a long period, so it will take similar timescales to bring appropriate construction industry use cases to market.

The other consideration for new materials is whether different modern technologies are more appropriate. Steelcase , a furniture manufacturer, is currently developing products using rapid liquid printing, a new manufacturing methodology being researched by a team at MIT . One of the reasons the company has focused on this technology is its ability to print large objects in minutes rather than hours.

Into the future

Anticipating the technologies that will prevail in the future is challenging. Use cases need to be developed, prototypes designed, developed and tested and the regulatory environment navigated successfully in an industry that is traditionally undercapitalised and unable to invest in research and development in the same way as the car or aerospace industries can.

The starting point is the manufacturing of larger subassemblies off site, subsequently put together on site using large-scale robotics. The site of the future will be radically different before we know it.

Dale Sinclair is Director of Technical Practice at Aecom

Further information

- Related competencies include Construction technology and environmental services
- This feature is taken from the RICS Construction journal (Sept/Oct 2017)
- Related categories: Building information modelling (BIM) , Modern methods of construction , Environmental management and policy