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How precast discovered digital

Undergoing a digital revolution

Image credit: FP McCann Ltd

The potential of BIM and digital technology is being embraced across the precast sector – leading to faster design and construction, more innovation, and better quality.

Over the past couple of years, precast concrete has been quietly undergoing a digital revolution. Since the government mandated BIM on all major public projects in 2016, precast specialists have been investing in technology and training, and the sector is now one of the most advanced adopters of digital technology in the construction industry.

From complex architectural details, such as the façade of Techrete's V&A Dundee, to structural cores, including Creagh's new HSBC headquarters in Sheffield, and even modular housing kits like Sterling's HexxHome – precast concrete firms are delivering services across a wide range of projects using BIM and digital technology. And they may have only scratched the surface of its potential.

"Precast is perfectly placed to exploit BIM," says Matthew Butcher, environmental and technical officer at British Precast. "Precast firms are working in a controlled factory environment, which is ideal for the principles of design for manufacture and assembly."

BIM software house Trimble, whose Tekla product was used on the V&A Dundee, agrees that there are exciting digital possibilities for the sector.

"Our software has been developed with each precast construction stage in mind, from design and pre-construction through to when the building is erected on site," says business manager, Ismail Makda.

"Digital construction can also facilitate the workflow between different stakeholders on one project. An architect can send their 3D model to the precast firm, who can create a highly detailed model with all the embeds, reinforcement, and so on, and at the same time, the engineer can use the model to assess the structural characteristics of the proposed building, such as wind loading."

FP McCann became the first precast specialist to achieve BIM Level 2 accreditation with BSI, two years ago, and completed its first BIM Level 2 project last year, a warehouse job at the Daventry International Rail Freight Terminal (DIRFT). Senior technician Colin Mackenzie says the BSI accreditation helped formalise FP McCann's internal processes.

"We have created clearly defined roles and responsibilities, as outlined in PAS 1192, to ensure project control," he explains.

FP McCann has worked hard to implement BIM and it is starting to pay off. "The shift to working in a data rich 3D environment has created significant additional work, training people in new software and developing components with embedded data," says Mackenzie. "Benefits have included clash detection, for example, on industrial schemes, allowing steel frame issues to be highlighted early."

The company typically works with the architect's 3D model, or on industrial projects the steel fabricator's model, and Mackenzie saying federated models are rare.

"We generally work at LOD (level of detail) of 4 or 5," he says. "More recently, we have started receiving received BEPs (BIM execution plans), where the LOD and LOI (level of information) have been specified for various project stages."

On the DIRFT scheme, Mackenzie adapted Tekla's software to speed up design of bespoke precast units, from the usual two hours to "just a couple of minutes".

Mackenzie says FP McCann's greatest gain from BIM adoption has been the parallel development of internal production processes.

"Using the embedded data in our Tekla software, we have been able to transfer information to lasers allowing quicker and easier mould set up," he says. "Additional investment in data driven mesh/rebar machines, adopting simpler reinforcement configurations, will accelerate rebar cage fabrication. On box culverts, we've reduced cage fabrication time by 50-60%."

The next step in FP McCann's BIM transformation is coordination with logistics. "Software firm StruSoft has supplied us with their Impact system, which links with our modelling data, and allows our planners to assign units to casting beds in the factory and then link up with deliveries to site," Mackenzie explains.

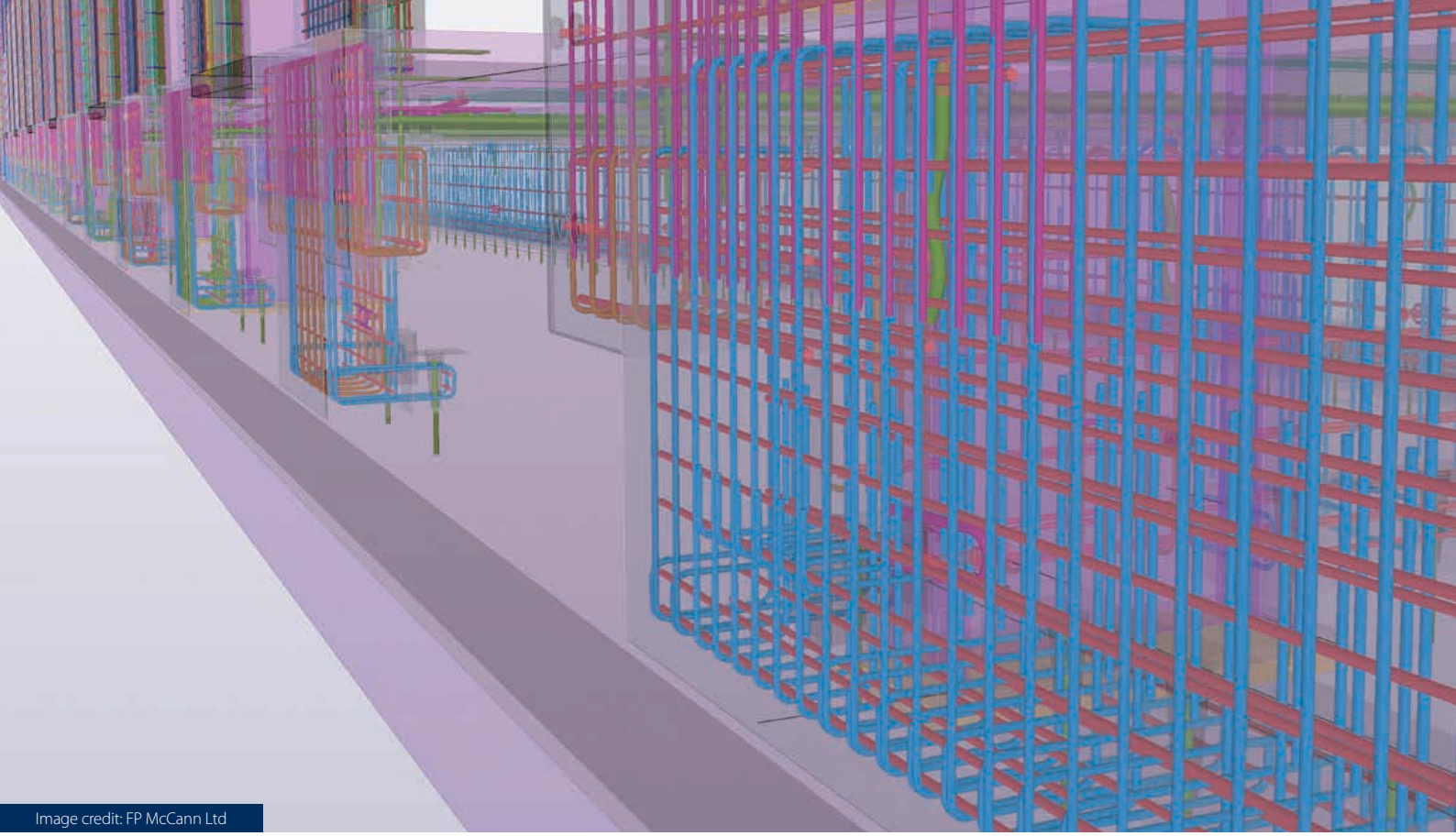


Image credit: FP McCann Ltd

Meanwhile, Creagh is also seeing advantages from BIM adoption. Connor McMahon, project manager on the company's digitally-driven Sheffield HSBC project, says the business has committed to implementing BIM across the business.

The firm uses Autodesk's Navis Works and BIM 360 Glue to coordinate design and highlight clash detection, and McMahon says he has appreciated being able to "extract and share information from the model, so we can work collaboratively with other design teams".

"The increase in productivity we've seen has increased Creagh's trust in BIM," McMahon explains. "We can work quicker, with more accuracy on cost build-up for estimates, reduced lead times, and improved timeframes during the critical path process.

"We are seeing better quality control, with a reduction in remakes and miss casts, plus we can be sure of ordering the exact quantities of cast-in components. BIM has promoted more sustainable and lean manufacturing processes internally."

Creagh has also developed an internal BIM library, with details of standardised components, which "improves BIM authoring in the design process", McMahon says.

To date, precast objects in the NBS National BIM Library have been mostly limited to infrastructure products, FP McCann, for instance, has uploaded pipes, rings and manhole covers.

However, Mackenzie says there is limited demand to extend the provision of standard components across other product groups.

He believes there needs to be more drive from clients for BIM to be fully implemented on projects. "We currently find that while there is intent, it is not necessarily followed through with full adoption," Mackenzie explains. "We have worked on three projects where the client wanted BIM Level 2 protocols, but the schemes did not end up being managed that way."

Makda feels there is still "a lot of work to do to enable external stakeholders to collaborate more effectively through digital construction". There is a culture of retaining certain information they consider sensitive, he says, but BIM is about "openness and transparency".

However, he adds: "I have observed a leap in the use of our software and clients finally realising the long-promised benefits." Makda feels most digital benefits to date have been at the preconstruction stage and thinks work onsite has so far been excluded. "There is great promise with new technologies like robotic total stations and virtual reality headsets," he says.

> "The increase in productivity we've seen has increased Creagh's trust in BIM."

Meanwhile, digital strategies in Westminster and among major clients would also seem to favour precast.

"The government is prioritising use of offsite manufacturing, and now wants a 'platforms' system of standardised components, while major clients like Heathrow are also moving in this direction," says Butcher. "Precast is a material and concept that can fulfil that vision."

"Consistency in construction methods and the subsequent cost savings is what is driving the Government's policy on DfMA – and it presents a unique opportunity for the precast sector," agrees Makda. "Standardised panels can be modelled and then stored indefinitely, ready to be used on buildings that have similar designs and layouts, high-rise buildings, schools and hospitals."

From an environmental perspective, precast also has a BIM advantage. British Precast has already created Environmental Product Declarations (EPDs), with life cycle assessment data, for several product groups, and these are expected to be used more commonly once the BRE Green Guide is discontinued in the early 2020s.

"In future, designers will be able to call up EPD data from all products on a project using the BIM model, and obtain up-to-date environment assessments on those materials to inform the specification," explains Butcher.

Meanwhile, British Precast is continuing to work with the Construction Products Association on Lexicon, the plan for a single data standard across all industry product categories.

Creagh's 3D-modelled cores speed up Bam programme

Digital aid for a £70m project

Image credit: BAM / Leonard Design Architects

Faced with a challenging programme on Sheffield's new £70m HSBC headquarters, Bam turned to Creagh to provide a BIM-modelled precast core.

Creagh Concrete has played a crucial role in helping main contractor Bam bring a flagship Sheffield regeneration scheme in on programme. And BIM has been central to the precast specialist's strategy.

Heart of the City II will be the new Sheffield headquarters of HSBC, and with the bank due to move into its new premises in mid-2019, programme was "absolutely key", according to Nick Howdle, construction manager for Bam on the £70.5m project.

Bam was appointed by Sheffield City Council to a preconstruction agreement in August 2016, before the design-and-build contract started on site in April 2017. Working with Leonard Design Architects, the contractor quickly decided to modularise key work packages, including the structural cores.

The scheme's 30,000 sq m main building sits on a sloping site, roughly triangular on plan, with a capacious basement and five above-ground levels. In-situ concrete was originally planned for the three cores of the superstructure, but Bam was a little nervous about the programme.

"The cores had to be finished absolutely on schedule, so we could move straight on to the steel frame," says Howdle. "So we decided to switch to precast concrete – just 16 weeks before the units would have to be delivered."

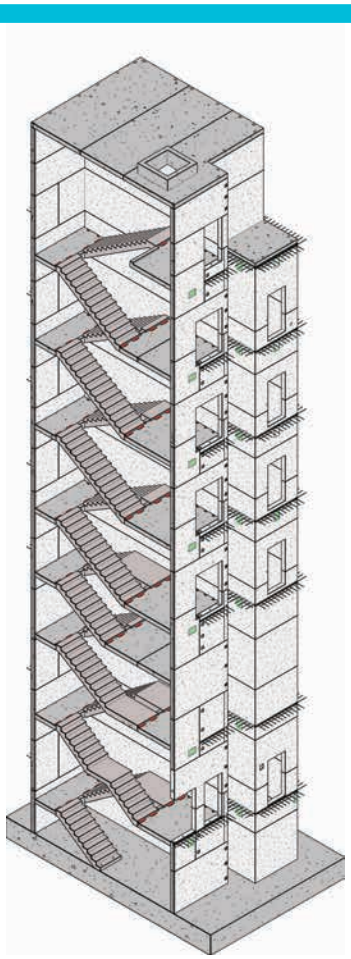
The contractor visited Creagh to explain the challenge. "We wanted to look at the factory and check the materials were right as this was such a programme-critical item," says Howdle.

Creagh's BIM manager at Sheffield, Connor McMahon, says the scheme was "was an opportunity for Creagh to use our digital capability to deliver high-quality cores while meeting a fast-track programme".

The cores are 34.5m-tall and each one has 17 precast sections, consisting of flat walls, 'C-shape' units, boxes, stairs, landings and capping slabs. The largest sections were 8m by 4.6m across and 2m high, weighing around 27 tonnes.

"We modelled the precast cores in Revit to LOD 5 (level of detail of five), which allowed Creagh to produce production drawings straight from the model," McMahon explains.

> "The model becomes an interactive tool, so we can visualise the product on the project virtually, before the prefabricated component is cast in the factory and arrives on site."



The cores sections also included cast in steel plates for the connections to the steelwork structure.

"We liaised closely with steel fabricator Severfield to guarantee that their steel plates were delivered in advance of our cast date," explains McMahon.

McMahon says the use of BIM meant a reduction in design and engineering costs, and an "improved service to our customer" through creating 3D visualisations of the project.

"The model becomes an interactive tool, so we can visualise the product on the project virtually, before the prefabricated component is cast in the factory and arrives on site," he says. "Creagh uploaded data drops to the common data environment (CDE) used on the project, so this provided Bam with evidence of how the precast cores had been developed."

Of course, the site assembly of the core sections needed to be accurate and the product quality was checked in Creagh's yard prior to despatch, McMahon adds.

Creagh also liaised with architect Leonard before applying a high-quality Type B finish on all the core elements, with some units having a mist coat applied.

Logistical challenges on the tight, city centre site included coordinating the high volume of large loads that had to be scheduled within a short time scale. "As a couple of cores were being fitted in tandem, it was vital the correct loads were delivered on time and off loaded efficiently to maximise installation time," adds McMahon.

The first of the cores was installed on site in just eight days.

"Credit to Creagh, they delivered," says Howdle. "It was a big help on such a tight programme."

Bam completed its contract at Sheffield in January and the building is now undergoing fit-out ahead of HSBC moving in.

VR and 3D modelling key to Sterling's HexxHome

Greater use of digital technology

Image credit: Sterling Services Ltd

Digital technology is helping to deliver Sterling Services' new offsite manufactured housing concept.

With a government drive for increased offsite manufacturing and standardised components, together with greater use of digital technology, the arrival of Sterling Services' precast housing system looks perfectly timed.

HexxHome uses pre-fabricated panels made from high-strength concrete. These are based on hexagonal forms which allows multiple configurations to be generated, resulting in the creation of many different building layouts, from studio flats to five bed houses. The precast components and housing designs are modelled in 3D using Autocad, which generates a VR (virtual reality) visualisation allowing designers, constructors and customers to 'walk though' an individual property or even a whole street of them.

"We see potential for HexxHome in the affordable housing sector as it is a robust, high-performance building with strong whole-life credentials" says Chris Bell, Sterling Services managing director. "We have a small scheme of four flats which has gone into planning with South Hams Council in Devon and we also have interest from the self and custom build market."

Conceived in 2014 and patented in 2017, the HexxHome system allows construction professionals or self-builders to design their home from standardised components without having to worry about the structural engineering, explains Phil Bent, HexxHome business manager.

"The pre-engineered slabs can fit together to create almost any shape of building," he continues. "We have an LABC/Premier Guarantee warranty for up to three storeys, but the structural capacity is there for multiple storeys. The slab edges have sloping, rather than 90-degree angles so when the wall panels are tied together, there are no lateral forces and they act as a composite I-beam.

"The ground floor slabs sit on piles or strip foundations; piling is the preference as that saves on additional concrete beams in the substructure. The layout is normally identical on all floors to carry loads down through the structure."

The panels use common mixes and reinforcement as Sterling Services eventually wants to license the component parts to other manufacturers. "We include fairly standard architectural mixes which we use in the Sterling Services factory in Taunton," says Bent. "GGBS or PFA cement substitute can be used but it is extremely important that we build to British and Eurocode standards."

Once the monolithic shell is constructed, insulation is fitted to the slabs followed by a batten void for the varying services and finally plasterboard. The wall panel dimensions, typically 2.9m high by 2.6m wide, have been designed to minimise cutting of insulation, plasterboard and skirting boards.

Image credit: Sterling Services Ltd

"The idea is to keep it simple, so that it is straightforward for a self-builder as well as an industry professional," says Bent. "A three-bed home can be assembled using a mobile crane and can be watertight in as little as two to three weeks."

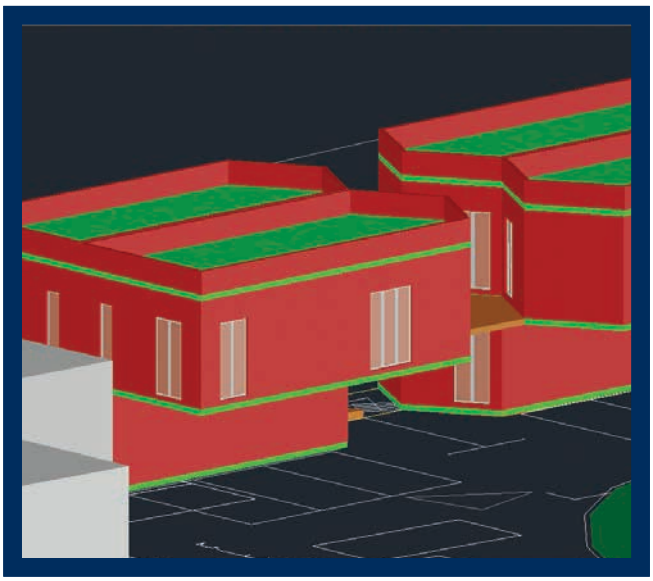
The wall panels can be faced in brick slips or various concrete finishes, which typically takes place in the factory, while timber facades can be attached on-site using cast-in sockets. The rooves are flat, structural slabs, with a BBA approved synthetic roofing membrane; this can be used to support solar panels or be used as an amenity space. "The style of our offering is more contemporary than traditional," Bent adds.

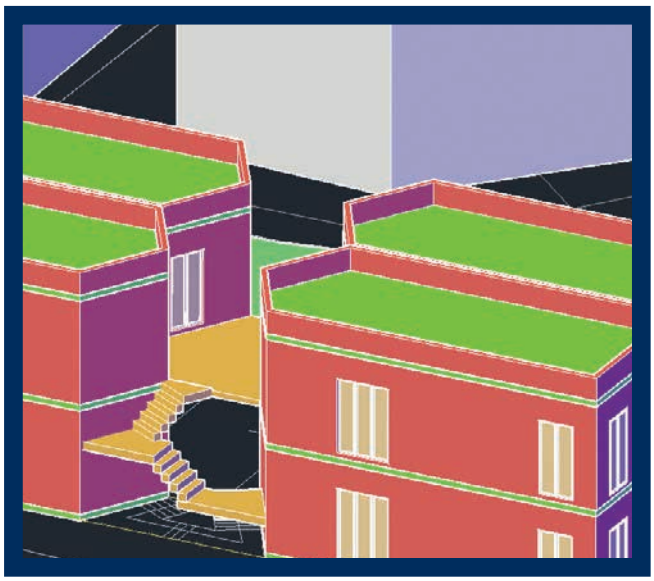
The concrete construction, along with the roofing membrane and mastic joint sealants, means exceptional airtightness and strong thermal performance with 'U' values of just 0.12 W/m^{2}k.

"The building fabric is at Passivhaus standard and the acoustic insulation is also fantastic," says Bent. "Use of dry joints also makes it easy to rearrange the building layout - for example, if a family wanted to extend their home."

The turnkey cost of a HexxHome starts from £1,650 per sq m and the various design options can be visualised by the prospective clients using Sterling's VR system.

During 2019, Sterling Services will develop its digital approach further by partnering with suppliers who also work in BIM. "Companies like Velux and Polyroof will provide us with BIM products which we can drop straight into our model," says Bent.





FP McCann's BIM ingenuity speeds up industrial job

Accelerating the design process

Image credit: FP McCann Ltd

Working with Tekla software, FP McCann was able to accelerate the design process for bespoke precast units on a Daventry logistics hub, its first BIM Level 2 project.

A recent FP McCann industrial project in the East Midlands demonstrated the precast specialist's ability to work flexibly within BIM software to create quick and innovative design solutions.

Phase III of the Daventry International Rail Freight Terminal (DIRFT 3) is a vast, 345-hectare construction project, where the developer is property and logistics giant Prologis.

For one of the warehouses, FP McCann was required to design and construct a series of precast concrete dock leveller pits. These allow access for delivery vehicles which are at different heights to the loading dock or require a bridge across the gap between the dock and the vehicle floor. With a variety of transport using the warehouse, loading docks need to accommodate many different vehicle sizes.

The precast concrete pits are formed from a combination of perimeter retaining walls and biscuit slabs, which support a dock leveller ramp that connects to the delivery vehicles. To accelerate the design of the precast units, FP McCann's senior technician Colin Mackenzie came up with a novel approach using Trimble's Tekla software.

"Tekla is a very robust program, which can be used to model anything, and using its custom component editor, it's possible to make big efficiency savings in the design," he explains.

The custom components editor is an intelligent tool that allows dependencies to be built between objects in a model, so that if the size of one component is changed, other dependent components will automatically be adjusted too. On a precast project with many bespoke units, but which all share common characteristics, the custom components editor can be used to speed up the design considerably.

"On DIRFT 3, there were, for example, 77 T-wall (front wall) sections required, of which 30 were bespoke," explains Mackenzie. "Each one would have taken two hours to model individually. Instead, at the outset of the design process, using the components editor, I modelled the geometry of the precast units and defined possible parameters for the bespoke elements.

"Then, when the designers began work, they would be presented with a dialogue box – as you would find in any Windows-based program – which allowed them to define the bespoke requirements of each unit, such as different dimensions, fixing positions, and so on.

"Working this way, we were able to design each unit in just two minutes. The total modelling took less than a week."

The largest precast units on the project were the giant 'Prowall' sections, which span between the pits, and measure up to 8m long and 4m high on average. Varying in thickness from 275mm to 335mm, they comprise two skins of concrete and an insulation layer. "Each section requires 100 Thermomass ties between the concrete and insulation layers, in specific spacings, which we were able to model quickly in Tekla," says Mackenzie.

The T-wall units required a bespoke design for the reinforcement to allow for a services channel to be threaded through (see image).

FP McCann also has an interface between Tekla and its rebar bending machines, which adds further efficiencies to the design and manufacturing process. "Tekla can supply the data to the industry standard PXML, which is fed into the machine and then the correctly-formed rebar comes out of the other end," says Mackenzie.

"We are also able to export from Tekla into IFC models, which we did on the DIRFT 3 project, which allowed the contractor, engineer and architect to coordinate construction activities on site," he adds.

"We are now certified to work at BIM Level 2, through BSI, and this was our first Level 2 project."

The next step in FP McCann's BIM transformation is coordination with logistics. "Software firm StruSoft has supplied us with their Impact system, which links with our modelling data, and allows our planners to assign units to casting beds in the factory and then link up with deliveries to site," Mackenzie explains.

FP McCann's dock leveller pit system at DIRFT 3 was supplied from its production facility in Byley, Cheshire and installed by its specialist on-site team. The project completed last year.