Laing O'Rourke, Steetley, Nottinghamshire S80 3DT, England

Precast Factory Explore Manufacturing, Laing O'Rourke (Part 2/2)

Laing O'Rourke is the largest privately owned construction solutions provider in the UK. Employing over 30,000 people across Europe, the Middle East, South Asia and Australasia, the company's operations span five core sectors: lifestyle; business; social infrastructure; transport and mining; and energy, utilities and waste.
In March 2010 the company opened Explore Industrial Park, a state-of-the-art new precast factory in the East Midlands, built to strengthen the company's offsite manufacturing capabilities and to support its construction projects across the UK.
The first part of the two-part plant report in CPI 4-10 describes project development and the two pallet carousel plants. The second part in the next issue of CPI supplements the report with a description of the control system, static production of bespoke architectural products, reinforcement production and the batching and mixing system.

Markus Obinger, Prilhofer Consulting
Roberto Bernardinis, A.W.M. S.p.A.
Wolfgang Cieplik, Unitechnik Cieplik & Poppek AG
Hans-Jörg Vollert, Vollert Anlagenbau GmbH + Co. KG
Hermann Weckenmann,
Weckenmann Anlagentechnik GmbH + Co. KG

Control System

For the two automatic circulation systems Unitechnik supplied the complete instrumentation and control. Each circulation system is coordinated by an UniCAM control system.

Employed in the complete control system are a total of three Siemens Simatic S7-400 controls and one Beckhoff control (for the highly dynamic Twin-Z robot from Messrs. Weckenmann) as well as six touch panels. Communication between the system components is achieved in all cases via Ethernet.

Operating Concept

The objective was to achieve an operating concept that was as intuitive as possible. In other words it should be possible for operating techniques to be learnt rapidly, for these to be self-explanatory and for the whole to be multinational. These requirements were fulfilled by the employment of touch screen operating throughout the system. All the relevant system parts are displayed graphically. The current position at any time of machine parts is visualized and the switching state of sensors displayed. For the manual initiation of movements - as is carried out in manual and setting-up modes - all that is necessary is to place one's finger on the screen. Naturally the terminals also provide an overview of the complete plant. From the overview one can zoom in to individual places and machines. In this way the place loadings and the causes of malfunctions can be analyzed in just a few seconds. Safety-relevant functions such as for acceptances and for an emergency stop are carried out as always with mechanical buttons.

Safety Engineering

Safety is Laing O'Rourke's number one priority. This was made clear at the commissioning. Thus, for example, strict attention was paid to the fact that everyone on the construction site was wearing his complete set of protective equipment (hard-toed boots, helmet, goggles, high visibility jacket etc.). For the plant too a very high standard was set for the safety engineering. Installed was mGard from the firm of Fortress Interlock. This system for heavy duty applications consists of modular robust trapped key inter-

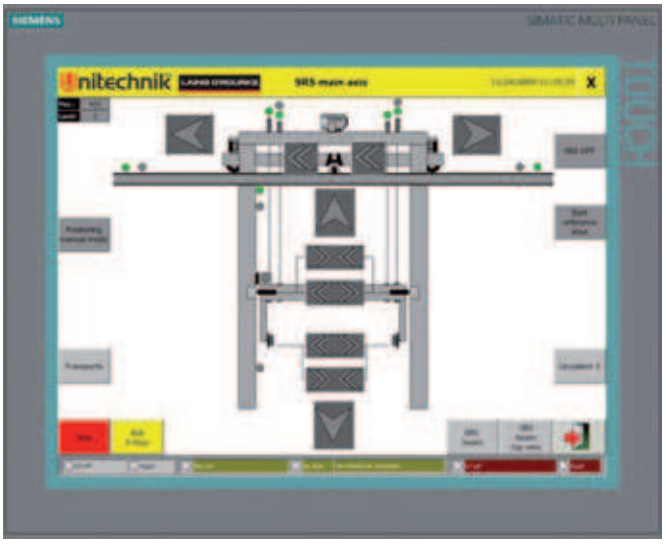

Fig. 24: Operating of the plant via touch-screen panels

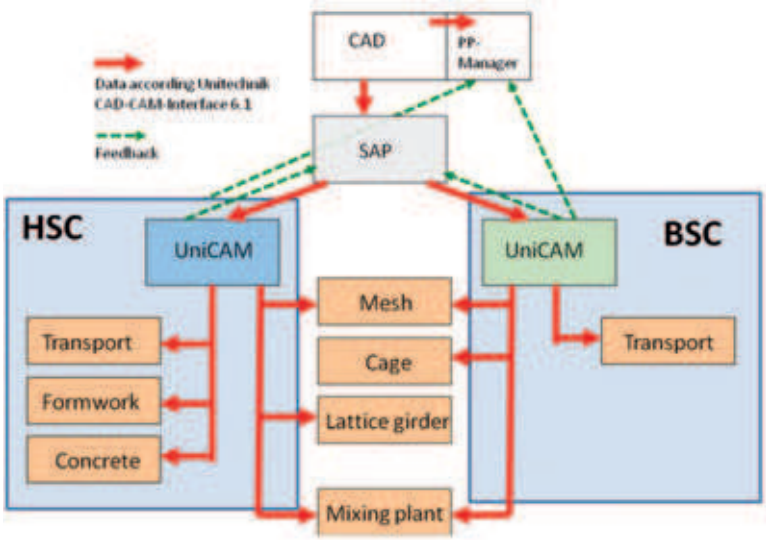

Fig. 25: Simplified schematic of the data concept for the two circulation systems

locks. The system uses keys which are interlocked or, as the case may be, released vis-à-vis one another mechanically in accordance with a preset sequence. At one individual access door one key is released after the plant part has been switched off; this is used to unlock the access point. The key can only be withdrawn when the door is closed. The plant part cannot be switched on until the key has been interlocked again in the key switch.
A total of 25 safety areas have been defined. These are fenced in to a large extent. Access for persons is achieved via access doors which are secured with the mGard system described above. Openings, through which the pallets move, are secured with light curtains in order to ensure that persons cannot get into the safety area from the conveyor system side. Naturally the plant is also safeguarded via a multitude of emergency stop buttons. These have been grouped together in a total of 12 emergency stop circuits.

Data Concept

The data concept represented a special challenge in this project. Accordingly Unitechnik were commissioned by Laing O'Rourke to develop the data concept jointly with the Laing O'Rourke experts.
The following components had to be taken into account in the data concept:

- CAD system Allplan from Nemetschek
- PP-manager from Nemetschek
- SAP as central manufacturing control system
- UniCAM master computer for the HSC
- Unitechnik controls for the HSC
- (Twin-Z robot, concrete distributor, pallet circulation)
- UniCAM master computer for the BSC
- Unitechnik control for the BSC pallet circulation
- Mesh welding system from AWM
- Cage bending system from AWM
- Lattice girder welding system from AWM
- Concrete mixer from Skako

Employed for the interfaces is the Unitechnik-CADCAM 6.1 format. Contained in this version for the first time are also parameters for complex reinforcement cages. In this way data is maintained in an integrated manner from the CAD to the production of the reinforcement. In essence the data flow is carried out as follows:
In the CAD system the elements to be produced are generated by the building drawing being divided up into individual elements. This information is recorded in parallel in the PP manager. The PP manager visualizes the degree of fabrication of a building in a clear manner by colouring in each element to be produced.
From the CAD system the data are transferred into the SAP system. The SAP system carries out the superordinated production scheduling. From here order stacks are sent to the two UniCAM master computers in the HSC and BSC.
The data needed for the carrying out of "its" order is distributed by master computer to the controls of "its" system, i.e. the controls of the formwork robot, concrete distributor and pallet circulation. Supplied in addition with data are the central machines which supply all the different parts of the plant. These are the reinforcement machines and the mixing system.
When the production status of a part changes, this information is fed back. The controls feed back to the particular master computer and the master computers feed back to the SAP and the PP manager. This ensures transparency in the production and permits reliable planning.

UniCAM Master Computer

The brain of each of the two pallet circulation systems is a UniCAM master computer. This manages the stack of orders, generates the optimum production sequence, optimizes the loading of pallets, supplies the machines with NC data and ensures the smooth flow of materials. The production can be configured individually via work schedules.

The information management provided by UniCAM supplies the works manager and the maintenance department with all important facts and evaluations: production quantities, consumption figures, disruption statistics, station time records etc. All the information can be called up on each office PC on the network. The feedbacks to the SAP system and the PP manager permit the information to be consolidated there and to provide a picture of the complete factory.

Bespoke Static Production Area

One bay of the building is reserved for the production of precast components in static moulds. The static moulds are used for production of bespoke architectural products like round or kidney-shaped columns, architectural edge beams, ramp edge units and units too large for production on the bespoke carousel system. All products that require a fair faced finish on all four sides or round shaped product need to be produced in static moulds in vertical position, as this is the only solution to achieve the same quality and level of surface finish on all sides.

Fig. 26: UniCAM master computer – the brain of a circulation system

Fig. 27: Longitudinal Bar Feeding

The moulds are specifically designed for the bespoke products. For columns Laing O'Rourke has developed a range of standard dimensions and a catalogue to select the best fit columns for the project. Of course any other dimension can be produced with some more effort for mould and reinforcement set-up.
Concrete pouring is done by crane operated casting bucket or by pumping the concrete into the moulds, especially for columns, where the concrete is filled from the bottom of the moulds. Product

Fig. 28: Welding Section

Fig. 29: Mesh Exit Bench and Pulling Carriages

Fig. 30: Mesh Crane and Buffer Store

finishing is directly connected to the mould area and includes for all before described surface finishes. Delivery of the finished products to the stockyard is done by Mafi trucks and trailers.

Reinforcement and Cage Production Area

Special Mesh Production

The line supplied by AWM belongs to the third generation of the well-known "Flexiweld" machines, specifically designed for the massive production of meshes for slabs and twin-walls.

The plant is composed by a multiple high-speed straightening machine "ST616/6" suitable for the preparation of longitudinal bars and by a special mesh welder. The multiple straightening machine can process six different wire diameters, from 6 to 16, starting from coils of hot or cold rolled wire of 5 tonnes. There are two types of uncoilers: static with uncoiling tower for wire up to 8mm and rotating, powered by variable-speed motors, for the larger-diameter wires. Each uncoiler is surrounded by a safety fence and it is possible to change the wire coils without stopping the machine. All wires are enclosed within long pipes in order to give the best safety protection to the operators.
The straightening is carried out by spinnars with hyperbolic rollers, suitable to process the wire without damaging the ribs, the cutting is provided by six independent flying shears, able to cut the wire without stopping its feeding and therefore increasing the performance of the line. It is also possible to run two or three lines at the same time in order to prepare bars of different diameter simultaneously. Longitudinal bars are then aligned and transported to the welding machine by means of special chains. Cross wires are fed off-coil in three different diameters and shot into the machine. The transversal positioning of cross wire is granted by a patented system that is giving a very good accuracy and speed. Wire size can be changed almost instantaneously within the same mesh panel.

The welding unit is equipped with 42 independent fix welding heads that can weld meshes with a minimum pitch of 50mm between the wires. The welding power is coming from a medium-frequency transformer controlled by an inverter. This welding technology allows an excellent welding quality and a balanced load on the electric line, with great benefit on the electric bills.

Once the meshes are produced they are pulled along the exit bench and placed in order to match the pallet. Two pulling carriages are dedicated to this operation, in particular the first unit is pulling the mesh during its production, the second is taking over when the mesh is finished and pulling the panel along the bench.

All meshes composing one pallet are picked up at the same time by a first special crane which can deliver the product to three different locations: the mesh buffer or two chain conveyors one feeding the BSC and one feeding the automatic mesh bender.

The buffer, hosting meshes up to 10 complete pallets, can be used both for the HSC and for the BSC, while the meshes for the automatic mesh bender are directly delivered to the feeding conveyor. In case the meshes are stored for the HSC, the buffer will be unloaded by a second special crane, thus increasing the efficiency of the plant because the first crane is always available to take the meshes from the machine.

Cage Production

A significant amount of products made in the BSC and in the static production area is composed by columns and beams. Since the beginning of the project LOR was interested in the automated mesh bending technology provided by AWM and by its innovative "Autobend" machines, because the traditional production of column and beam cages is very labour intensive and it requires high-quality and skilled workers.

An "Autobend 4200" was therefore installed to produce cages and shaped meshes. The machine is fed automatically with the mesh coming from the welding machine: the mesh is delivered by the automatic crane onto a long chain conveyor that is used both as a buffer for different mesh packets and as a transport system. The machine is automatically picking the meshes from the packet, bending and stacking the finished product. All production data are provided by the Master Computer, while the software to control the machine is an exclusive technology of AWM. The main feature of the "Autobend 4200" is the possibility to produce very complex cages thanks to a patented system suitable to shift the bars laterally and avoid collisions. The mesh feeding is provided by three independent carriages working in sequence, thus ensuring the high productivity that is required. Thanks to the quick-change features available on the machine it is possible to run very small batches, an ideal solution for a precast factory.

Fig. 31: Cages Produced on AWM Autobend

Fig. 32: AWM Autobend Closing Cage

Fig. 33: Lattice Girder Active Store

Fig. 34: Lattice Girder Placing Robot

Lattice Girder Processing

Lattice girders are necessary for the production of slabs and twin walls in the HSC, and they are automatically supplied by an AWM "BWC" machine. The equipment, remotely programmed by the Master Computer through a "Unitechnik"-type file, can automatically select the desired girder from a stock of 16 different types, then cut it to the desired length and butt-weld the remainings with the next girder in order to eliminate wastage. The machine can automatically adjust the welding parameters when the type of the girder changes, thus giving a good-quality welding with no need of manual settings. Once the girders are cut, they are automatically stored in a buffer where an automatic placing robot will pick five girders at the time and place them into the two lanes of pallets. Girders can be automatically rotated of 90° wh

Fig. 35: Cage Assembly Area

Fig. 36: Skako Concrete Batching Plant

walls are produced. In addition to the "BWC" machine, the factory is producing standard and special lattice girders with an AWM lattice girder machine type "ARM 200 VSX". This machine can produce the girders up to a height of 400mm with wires up to 16mm. It is also possible to produce girders with two upper longitudinal wires in order to improve the static performances of the final product. The girders produced in the factory are partially used for the precast plant and partially shipped to other construction sites.

Cage Assembly

Reinforcement products, mainly reinforcement cages, for the Bespoke Carousel System and for the Bespoke Static area are pre-manufactured in the cage assembly area so that at the workstations in the carousel system and at the moulds in the static area ready made reinforcement cages only need to be lifted and fitted into the moulds.
The cages are produced from the pre-formed cages from the AWM Autobend machine, additional required single links delivered from an EVG link bender and the structural bars up to 50mm diameter from a big Stema Pedax shear line with connected manual and semi-automatic bending lines. All materials are bundled, labelled and collected on trolleys and are then delivered to the specially designed Hobl Cage assembly machines and assembly tables, each one linked to a welding unit. The cage assembly machines pick-up the delivery trolley for pre-manufactured cages and serve for handling the cages during assembly of the additional links and structural bars as well as for delivery of the finished cage to the place of use in the BSC and in the static area.

Fig. 37: Skako "Conflex" Concrete Delivery System and Bibko Recycling Plant

Batching Plant and Concrete Delivery System

The concrete supply for the factory is done by a Skako batching plant. The batching plant is designed as a high silo plant and is tailor made for the requirements of Laing O'Rourke with regards to concrete volumes, concrete types and different aspects like fibre reinforced concrete, SCC, coloured concrete and others.

Some key data of the concrete batching plant:
- Fully clad high-silo plant
- 2 x 3.000 litre mixers with two outlets
- Aggregate storage in high silos with a total capacity of 1.440 m³. The aggregate storage consists of 13 bins with 90m³ each for the most used types of aggregates and sand; six bins with 45m³ each for low demand aggregates. Additional exchangeable hopper system for special aggregates in low volumes
- Steel fibre dosing system
- Cement storage in four silos of 100 to capacity and one silo of 100 to capacity for white cement, being fed to both mixers
- Filling of readymix truck possible to feed civils yard
- Concrete bullet delivery on two strands → two bullets used from existing tunnel project equipment for BSC and hopper feeding to future pump installation
- One bullet on a separate strand delivering concrete to the HSC
- All three bullets can take concrete from both mixers
- Service platforms, automatic high pressure cleaning system for mixers and concrete bullets

Product Surface Finishing Area

A big portion of products from the BSC and static area require a sandblast finish on one or several sides. To cope with this high demand of sand-blasted product a sand-blasting booth has been installed in the factory building. The sandblasting booth is a stand-alone structure including the booth and crane runway structure for

two 10-ton cranes. The heaviest parts for sandblasting are therefore 20 tonnes, up to 4m in height and up to 12m long. A delivery trolley is feeding the product into the booth and unloading the finished product at the other end. A man lift is installed at both walls of the booth which allows the operator to safely reach all areas of even the largest pre-cast units. The blasting material is collected through a conveying system and will be recycled for re-use. Worn out blasting material will be automatically separated and collected for disposal.
Other processes like exposing aggregates, jet washing of retarder paper from stone or brick-faced wall panels and acid etching is done in separate enclosed areas to protect other areas from water spray and contamination. The process water is collected in large sumps equipped with special pumps and a control system for flushing the sump pit to keep solid parts in suspension and is pumped back into the recycling plant from Bibko. The recycling plant is also collecting the wash-down water from casting equipment and the cleaning processes of the mixers and the concrete delivery bullets in the batching plant. Sand and aggregates are separated by the recycling plant and the remaining grey water is collected in a steel tank with agitator to avoid settlement of cementitious contents. If the grey water can not be used in new batches due to the high architectural requirements for the precast units the grey water is processed through a filter press and is then disposed to the sewage system as clear water.

Stockyard

The stockyard is operated by three goliath type gantry cranes each taking care of one storage bay and two truck loading bays. The cranes have 40m span to maximize the use of the storage area. Two cranes each with 15 tonne capacity are handling products from the Bespoke Carousel System and the Bespoke Static area. The 15 tonne cranes were existing from the previous tunnel segment factory in the London area and have been reassembled and refurbished to be used for the new Steetley factory.

A new 40m span gantry crane with 32 tonne lifting capacity is handling the products delivered by the run-off truck of the High Speed Carousel. The transport units are compiled in the factory ready for delivery to the construction sites and no handling of individual precast components is required on the stockyard. The crane is designed with 10m cantilever on both sides to operate the loading and unloading bays for the delivery trucks. The crane leg span allows also for the transfer of the longest precast components produced in the HSC.

Fig. 38: Sand-blasting Booth

Fig. 39: Stockyard Crane Bespoke Static

Safety Standards

One of Laing O'Rourke's key drivers is the health and safety of their employees. Under this impression the whole project development and design of the factory has been carried out. In the first project phase a detailed design risk assessment has been carried out for each machine installed in the factory. The design risk assessment covered the whole life cycle of the equipment from installation and operation until potential future disassembly. For the installation of the equipment and heavy components methods statements have been prepared by the equipment suppliers in cooperation with the experts of Laing O'Rourke. Especially the installation of equipment and required documentation was driven by the UK Construction, Design and Management "CDM" regulations.

The risk assessment for each machine analysed in depth the requirements for safe operation of the machine, the accessibility of all machine components in case of maintenance and repair, e.g. the hoist and gearbox of the rack operators and safe lifting of heavy machine components like drive motors in case a replacement is required. This led to a number of design changes on the installed equipment.

After the design risk assessment for the individual machines the whole process has been analysed with regards to manual work zones and zones with automatic machine movements. Prilhofer Consulting have developed a safety fence and safety

Fig. 40: Safety Fence and Light Barrier

zones layout for the carousel systems and the reinforcement machines which has been further refined together with Laing O'Rourke. For the required pallet transfer between manual and automatic areas slots within the safety fences are required. Due to the size of the slots access into the zones would be fairly easy. Therefore horizontal light curtains have been installed behind all fence openings to prevent operators to step into the active safety zone. Clever positioning of the light curtains allows several openings to be secured using only one light curtain and makes the more complicated design of light barriers in muting mode unnecessary.

Fig. 41: Fortress mGard Access Key Exchange Panel

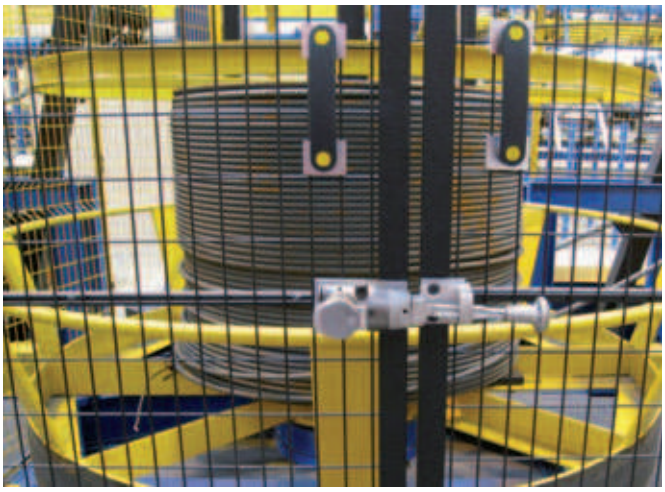

Fig. 42: Coded Key Access to Uncoiler

Each safety zone has a controlled access which is secured by the Fortress mGard system to make sure whenever an operator enters a safety zone all machine movements within the safety zone are stopped before the access door can be opened. Even more important is the fact that the system will not allow restart of the machine movements by a second person when the operator is still inside of the safety zone.
Floor marking clearly identifies all walkways, escape routes, vehicle loading zones and material storage areas. Each production unit has its own small maintenance area. The main spare parts stores for the factory and maintenance workshop is located on a mezzanine in the HSC area which provides more than 420m² of space.

Conclusion

With the development of the Steetley precast factory Laing O'Rourke has set a new benchmark for the industry. Optimized data flow and full CAD integration of all production areas and processes will improve the efficiency on the manufacturing side as well as on the management side of the business. The highest possible safety standards applied make this factory a new reference in the precast industry and provide a good working environment for the operating staff. This environment is essential to employ the skills needed to manufacture high quality precast components. The products and capabilities of the Steetley precast factory will help to enhance the value of Laing O'Rourke construction projects.