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Precast Factory Explore Manufacturing, Laing O'Rourke (Part 1/2)

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 describes the project development and the two pallet carousel systems in detail. The second part of the report in CPI 5-10 supplements the report with a description of the control system, static production of bespoke architectural products, reinforcement production, and the batching and mixing system.

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Laing O'Rourke is an innovative organisation that's passionate about moving the construction industry forward. Increasingly it is using modern offsite manufacturing to de-liver tailored solutions that exceed the quality standards of traditionally constructed projects.

By incorporating standard components into a building's design, even complex structures can be built faster, and at a lower cost to the client.

Fig. 1: Factory and Office Building

Fig. 2: Bespoke Precast Panel at Malling Products Ltd.

Moving activities from construction sites to controlled factory conditions also positively affects health, safety and environmental performance: processes are more predictable, risk is easier to manage, site congestion is reduced and a lot of material waste is eliminated.

In Explore Industrial Park, Laing O'Rourke now has its own world-class manufacturing facility that can deliver all these benefits to the business.

The Project Development

The first considerations by Laing O'Rourke for building a precast factory started with the idea of using the concrete batching plant and the factory building's steel structure of a tunnel segment factory which has been built to deliver components for a project in London. This factory had to be dismantled and was put in storage after completion of the tunnel project. Prilhofer Consulting has done an evaluation of the usability of the available steel structure for a new precast factory including a pallet carousel system and has proposed concept layouts for this factory. A detailed review of the proposals together with experts from Laing O'Rourke concluded that the processes developed under the given constraints of the available steel superstructure like low crane hook height, bay width etc. were suffering from a number of compromises to be made in the layout and the factory processes. Considering rebuild and adaptation cost when using the existing structures the potential savings were only minor compared to an investment necessary to build a completely new factory. At the same time the production processes developed had a number of disadvantages and therefore Laing O'Rourke took the decision to have the factory designed and built from scratch to achieve the best fit for the own needs and to have a highly efficient production

Fig. 3: Overview 1 Bespoke Carousel System

system available that can cope with the requirements set out. The re-start of the factory design process included a number of activities where only a few key- activities are described below.

The layout design process by Prilhofer Consulting and Laing O'Rourke went hand in hand with the analysis of the products to be produced in the new factory as the most important design input. A product profile has been set up which listed all planned products in their typical dimensions as well as min-max dimensions and planned volumes per year according to a production ramp-up plan which has been developed in parallel. A range of standardized components was developed with input from precast specialists at Malling Products Ltd, a subsidiary of Laing O'Rourke that was already manufacturing precast products as well as design and construction experts from the wider business.

With the firm input of the product profile and the exactly defined capacity requirements the factory layout could be refined and the designed processes have been taken under further evaluation and development. The expected production times and staff requirements of the planned automated or semi-automated processes have been compared with the timings and staff required for the traditional production methods in use at Malling Products Ltd. This was required to make sure the installed processes make economic sense and the set out requirements for return of investment can be achieved. The developed layout has been double checked with a detailed simulation model and various shift patterns and their effects on productivity of the factory have been considered.

A big focus was given to the product finishing requirements for the precast components, especially for architectural concrete. The factory includes areas for processes like sand-blasting, acid etching, exposing aggregates, hessian rub, stone faced panels and other architectural surfaces. Adequate and efficient processes have been included in the factory layout.

Fig. 4: Factory Building with Skako Batching Plant and Civils Yard

After the factory layout and all machine and performance requirements have been fixed a specification document has been set up for each part of the factory like carousel systems, reinforcement machines like mesh welding plant, concrete batching plant and concrete delivery system, overhead cranes for the factory, etc.

These specification documents were an essential part of the tendering process to achieve comparable quotations from all relevant equipment suppliers invited to quote for the project. The evaluation of the quotations was concluded with a detailed supplier assessment process and negotiations to fix the contracts with the chosen partners for the project.

The Factory

Based on the production requirements and products the factory consists of the following production areas:

High Speed Carousel System "HSC"

Pallet carousel system designed for eight pallets per hour for the production of insulated / non insulated twin walls and lattice girder floor slabs.

Bespoke Carousel System "BSC"

Pallet carousel system designed for three pallets per hour for the production of so-called bespoke products like solid walls, sandwich walls, façade panels and volumetric products like columns, beams, stairs, terrace elements, lift shafts etc.

Bespoke Static Production Area

Production area with static moulds 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.

Batching Plant and Concrete Delivery System

High silo plant with two mixers 2m² per batch and two outlets each is producing the required concrete for the precast factory. A concrete bullet delivery system is feeding concrete to both carousel systems.

Reinforcement and Cage Production Area

The production of the required reinforcement for the factory is done with a big mesh

Fig. 5: Overview High Speed Carousel System

Fig. 6: Pallet HSC

Fig. 7: Shuttering Robot

Fig. 8: Manual Workstation Following Shuttering Robot

welding line, a lattice girder welding machine, a lattice girder cutting line and placing robot, an automated cage bending machine bending cages from flat mesh, a shearing and bending line working from stock bar and a cage assembly area equipped with several cage assembly machines.

Product Surface Finishing Area

To achieve the required architectural finishes on the products several processes for surface finishing have been installed like a big sandblasting booth, a booth for acid etching, an area for exposing aggregates, workstations for cosmetics and hessian rub.

Civils Yard

Products too heavy or too big for the internal factory operations and cranes are manufactured on the so-called civils yard. This area is also serving to produce pre-stressed components.

High Speed Carousel System "HSC"

The so called HSC is a pallet carousel system with short cycle times and for products with very similar cycle times at the manual workstations which is given for twin walls and lattice girder floor slabs. The designed capacity of the pallet carouse system which is operating with two lines from shuttering robot up to the concrete spreader is eight pallets per hour.

Fig. 9: Concrete Spreader and Compaction Stations

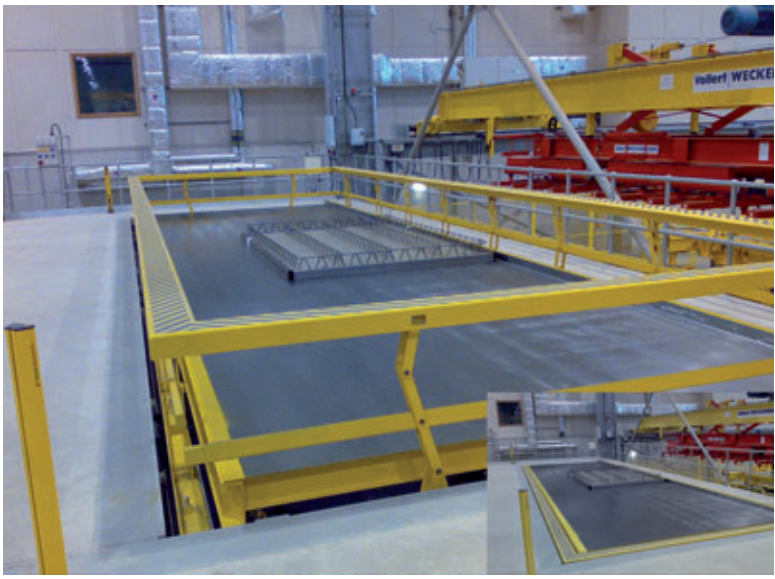

Fig. 10: Pallet at Mezzanine Level

Pallets in the HSC and in the BSC have basically the same structure, adapted to the individual surface load requirements. The pallets consist of two main longitudinal beams, a number of stiffening transversal beams and a steel sheet cover made from one piece in excellent quality. The pallets have been produced in hall No. 8 of Weckenmann company which has been designed to purpose for manufacturing of steel pallets and has enabled the on time delivery of 106 high quality pallets (HSC + BSC). Especially the grinding surface pattern and the evenness of the pallet steel sheet is the most important criteria which determines the quality of the precast panels at the end of the day.

The delivery of the pallets as excess width transports due to 4m pallet width has been organized by the Weckenmann logistics team in 36 deliveries to England including an escort vehicle.

The production process starts with a cleaned pallet in the shuttering robot station which uses the so-called Twin-Z robot system. The required throughput of the system of eight pallets per hour would have been a big challenge for conventional robot systems and would have left no spare capacities. The installed Twin-Z system is able to place shutters on eight pallets per hour and take care for the storing and unstoring of shuttering profiles. The key data of the system are quite impressive with a workable area of 25m x 4m, stroke of the twin-z-axis of 1 metre, rotation angle of 270° and cycle time for placing shuttering profiles on the pallets of only 18 seconds. The shuttering profiles are of 100mm height and are using strong integrated and switchable magnets. Covering profiles made of thin high-strength steel sheet are used for the telescopic closing of remaining shuttering gaps without the use of polystyrene or similar materials.

The trick to achieve the required performance is simple and efficient. The robot grips the shuttering profiles at the magnets and activates the magnets in the moment of

Fig. 11: Vacuum Turning Device

Fig. 12: Lifting and Vacuum Turning Device (During Assembly)

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Fig. 13: Rack Operator HSC

Fig. 14: Tilting Table with Man-Lift

accurate placing on the pallet without any further robot movement. This saves time, energy and wear of the system. The light and stable runway profiles guarantee minimal deflections of the system and huge stiffness even at large spans.
From the shuttering robot two identical parallel lines are used for the following processes like manual shuttering completion, placing of inserts and frames, automated placing of mesh reinforcement and lattice girders and manual completion of reinforcement and other accessories required for floor slabs and especially twin wall first shell pallets.

After all preparation work is done the pallets are sent to the casting stations where the concrete spreader is working over two pallet positions. The concrete spreader can work on one pallet while on the other station the finished pallet is exchanged with a new one. This eliminates waiting times of the equipment and increases the system performance.

The concrete spreader is using proven dosing technology with porcupine roller and valves for flow control. This allows the use of different concrete recipes and consistencies. Concrete distribution can be done over the full width of the spreader or limited to certain areas controlled by opening only certain valves. The system has a number of advantages compared to spreaders with distribution screws like reduced wear, two parameters for controlling concrete flow (valve opening and rotating speed of porcupine roller), more simple cleaning because of less parts in the concrete distribution section of the spreader and also less maintenance.

The operator is controlling the concrete spreader with a remote control system or when using the automatic function the operator has just a surveying function.

The concrete spreader crane bridge is designed to allow moving the concrete spreader bucket into a static transversal spur into a cleaning booth to avoid spray water in the working and equipment area.

Laing O'Rourke is planning to use a fairly high proportion of floor slabs with polystyrene void formers and insulated twin walls. These products will have the polystyrene placed on the wet concrete after the concrete has been poured. For this purpose a mezzanine has been installed behind the concrete spreader area. Pallets for this type of products will be lifted automatically into the mezzanine level by a hydraulic lifting station.

When there is no pallet in place a telescopic handrail is securing the opening in the mezzanine floor. The mezzanine serves as intermediate storage and preparation area for the polystyrene blocks used. If the percentage of insulated products is increasing there is a second pallet station at floor level available to double the production capacity.

The twin wall production area is located in a separate area and is independent from the production of other products. At the same time the connection to the curing rack for provision of the first shell elements is ideal as it is just on the opposite side of the rack operator and also the removal of the empty first shell pallets into the shutter removal line does not affect the flow of pallets for other products. For the production of the twin walls the Vollert vacuum turning technology is used. The vacuum turning technology offers a number of advantages compared to pallet turning, like less manpower requirements, less physical work required and possibility of production of twin walls with zero void. The control system of the vacuum turning device supports the operator by automatic detection of vacuum suction cups covered by the concrete panels and automatic deactivation of the vacuum cups not in use. A visualisation at the Unitechnik control panel helps the operator to double check the function of the system.

The hardened first shell elements are lifted off the pallet with the lifting device for first shell elements. This special crane can lift all elements on the pallet in one go and places them on the vacuum turning device. Spring loaded and gimbal-mounted hooks grip the panels at the upper bar of the embedded lattice girders and

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Fig. 15: Unloading Area and Run-off Truck

Fig. 16: Shutter Removal Stations

Fig. 17: Overview 2 Bespoke Carousel System "BSC"

guarantee a soft handling of the still "green" first shell panels. The operator has perfect control of the process because of the use of a radio remote control system.

For production of walls higher than 3.7m the lattice girders will be placed for 90° turned to their standard orientation. To handle these elements the crane hooks are mounted on four separate frames which can be individually turned by the operator through the remote control system. This provides full flexibility to the system for all product variations.

The finished pallets are delivered in the area of the rack operator which is a crane mounted design and is operating a fully clad curing rack. The fully automatic system is moving pallets into the curing rack for concrete curing and takes the product out again after the pre-set curing time. The temperature inside of the curing rack is controlled and kept to the required level by the direct fired heating and ventilation system by CDS Concrete.

For achieving a high factory output the most important area is the product unloading and shutter removal area especially when the factory is producing floors slabs and wall panels. The production process including concrete pouring is very similar for lattice girder floors and twin walls but when it comes to the unloading of the product from the pallets the required cycle times for handling floors and walls are very different. Therefore it is essential to have a layout of the unloading area which is compact on the one hand but is clearly separating the processes for unloading walls and floors on the other hand.

The layout of Prilhofer Consulting is achieving this by using two individual but parallel pallet lines in two levels to feed the pallets into the unloading area for the relevant product and the intelligent arrangement of overhead cranes and special lifting device for the floor slab panels is clearly separating the crane operations. The operators can work on both products independently without interfering with each other. This solution also protects the system efficiency from fluctuations in the product mix and allows to fully flexible change the ratio between wall and floor panels produced. The same is valid for the other areas of the HSC.

Floor panels are unloaded with a special lifting device equipped with a number lifting hooks mounted on individually controllable beams. The product is taken up by the upper bars of the lattice girders to allow a safe and stable lift without damaging the product. The floor panels are produced and laid to stacks according to a pre-defined sequence from the CAD-system.

Wall panels are unloaded from a tilting station which brings the pallets into a nearly vertical position. A frame mounted access platform allows the operator to safely reach the lifting points of each wall panel. To avoid operators having to climb up ladders to release the crane hooks after placing and securing the wall panels in the wall transportation racks a special spreader beam provided by the Nuspl company is used. The spreader beam is equipped with 5 remote controlled hooks and the operator can safely release the crane hooks by remote control without having to climb up to the top of the panels.

Finished floor slab stacks and wall transportation racks are delivered to the stockyard area by a so-called run-off truck. The run-off truck can pick product from eight deposit areas inside the factory. To pick up the floor slab stacks or wall racks the run-off truck is equipped with cross lifting trucks, going underneath the load and lif-

Fig. 18: Pallet and Central Transfer Car in Tunnel

Fig. 19: Workstations BSC

ting the load from the deposit blocks. When the run-off truck has left the building it sets down the units underneath the stockyard crane.

The layout of the wall panel unloading area also allows for the wall panels to be placed into inloader racks which can be picked up with the inloader trucks directly from the factory.

After unloading of the products the pallets are travelling to dedicated shuttering removal stations equipped with lifting assistors for the longer shuttering elements. All shuttering profiles are removed from the pallet and placed onto a 35m-long conveyor system which is transporting the profiles in several directions and also for more than 1 metre in height difference. It is a pre-condition for the good functi-

Fig. 20: Concrete Pouring and Finishing Area, Curing Racks

Fig. 21: Contour Checks at BSC Rack Entries

Fig. 21a: BSC Rack Operator

on of the shuttering robot that the profiles are transported fast, properly cleaned and oiled and the identification of profiles is precise.

Bespoke Carousel System "BSC"

The so-called bespoke carousel system is designed for a capacity of three pallets per hour for the production of bespoke products like solid walls, sandwich walls, façade panels and volumetric products like columns, beams, stairs, terrace elements, lift shafts etc. The BSC is a combination of a classic carousel system and a central transfer car system.

The mix of products in the BSC requires the flexibility of the concept using a central transfer car which is moving pallets to their dedicated workstations and allows for variable time for manual works carried out at the workstations without affecting the throughput of the whole system. The big variations in processing time occur during the mould set-up and assembly of reinforcement and fittings. Other processes like concrete pouring, compaction, surface finishing and mould cracking / stripping have more equal cycle times and are using the carousel part of the BSC. Also the distribution of products at the unloading and finishing end of the process requires the distribution capabilities of a traditional pallet carousel system.

The laser controlled central transfer car is operating in a tunnel over a length of 120m and is distributing pallets with the two cross lifting trucks installed to 10 individual workstations for mould set up and reinforcement installation as well as to the concrete pouring area and pallet cleaning area.

The central transfer car tunnel roof area with more than 800m² is used as mould storage and mould workshop area and is prepared to be equipped with five additional pallet positions, fed by the rack operator. This extension of the carousel system will be used for set up of specific moulds on pallets and for extended wet surface finishing processes by helicopter smoothener.

Many of the very specific precast components produced in the BSC are using specially and job related designed mould systems which remain on the pallet throughout the whole production process. At the manual workstations mould preparation and adaptation work is carried out for the next production cycle. Also set up of new mould systems and compilation of moulds from standardized shuttering components is done here.

The reinforcement cages are produced in the cage manufacturing are of the factory which is described below in more detail. The prepared cages are delivered just in time to the pallet work stations and just need to be lifted into the prepared mould. The reinforcement is then completed with additional accessories like shear rails, lifting anchors etc.

After completion of mould set-up, assembly of reinforcement and accessories the Vollert central transfer car picks the pallet from the workstation and delivers them into the concrete pouring area. The concrete pouring is done by crane operated concrete buckets. The big variation of products from low products with 20cm height up to 2m high product, wide moulds and narrow mould openings did not allow for the use of a typical concrete spreader. As a next development step the concrete pouring by crane operated bucket shall be replaced by a pumping solution.

A vibration station with pneumatic lifting device and 16 high frequency vibrators is compacting the concrete evenly and is transfer-

Fig. 22: Cosmetics and Finishing Area

Fig. 23: BSC Products on Mafi Trailers

ring compacting energy also into the very high and complex mould systems.

Following the concrete pouring area a wet finishing area is installed for initial screeding and smoothening work on the precast components. Products that require more intensive surface finishing can travel in a loop through the curing rack back into the wet finishing area after they have reached a certain setting time for final surface finishing.

Depending on the process steps following after the concrete pouring the pallet can use one of three entries into the curing rack. Each entry into the curing rack passage is secured with a contour check system that will immediately stop the pallet if any part of precast component or mould will be larger than the allowed system dimensions. This early check of dimensions would allow the operators to take remedial action before the system gets blocked by collision in the passage or a late detection of oversize units on the rack operator.

The rack operator is situated between the two fully clad and heated curing chambers. Due to the high load of pallets and precast components of up to 40 tonnes and the lower cycle time requirements the rack operator is designed as a floor mounted device. The rack operator is also opening and closing the segment doors of the curing rack. Standard height of compartments in the curing rack is one meter, in case of extra component height over 1metre and up to 2m two levels in the curing rack will be used for storing one pallet.

Cured products will leave the curing rack in two lines for mould cracking and mould removal, when required. From this two demoulding lines the pallets will then travel to one out of five unloading areas in three bays of the building. The unloading area for the individual product is mainly defined by the required surface finishing after unloading.

The five areas are defined as:

- Direct loading for delivery to stockyard or site
- Sand-blasting
- Acid etching
- Exposing aggregates or jet wash retarder paper e.g. from brick faced panels
- General cosmetics and hessian rub

Delivery of the finished products to the stockyard is done by Mafi trucks and trailers

Read the second part of this comprehensive plant report in CPI 5-10 with a description of the control system, static production of bespoke architectural products, reinforcement production, and the mixing system.

FURTHER INFORMATION

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

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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-

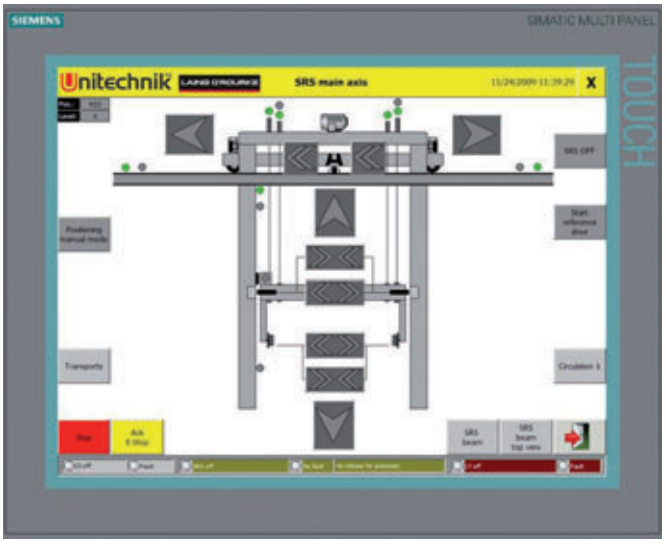

Fig. 24: Operating of the plant via touch-screen panels

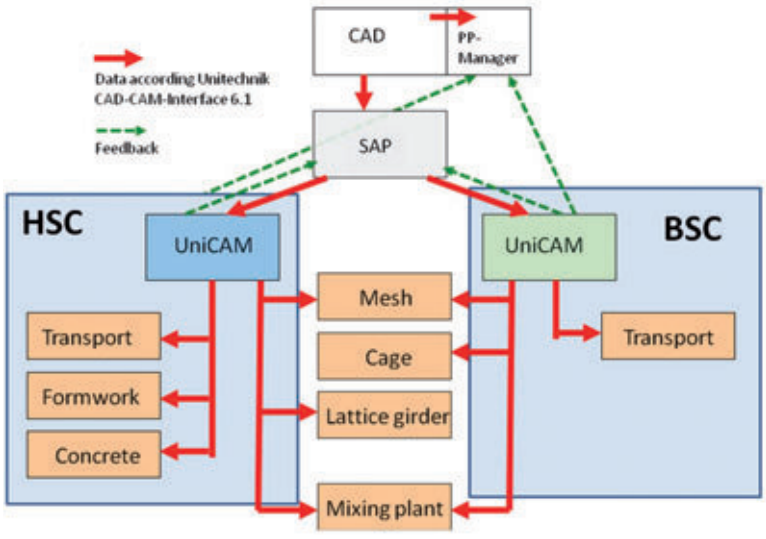

Fig. 25: Simplified schematic of the data concept for the two circulation systems

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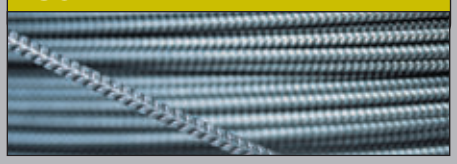
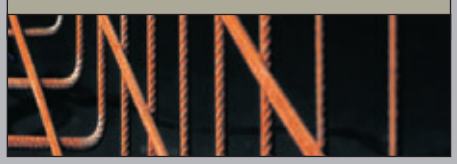


Automatic stirrup bending machines for processing of reinforcing steel coils.

BAR

Automatic concrete reinforcing steel bar bending and shearing machines.

MESH



Various bending and cutting reinforcing steel wire mesh processing machines.

MANUFACTURING

Automatic machines for round and polygonale pile cages and welded rollmats.

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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.

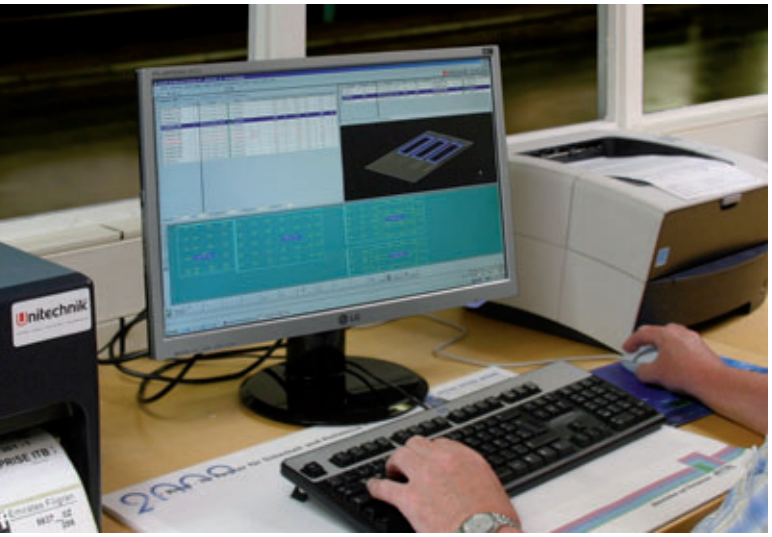

Fig. 26: UniCAM master computer – the brain of a circulation system

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° when double

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

Fig. 41: Fortress mGard Access Key Exchange Panel

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. 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.

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