Precast concrete component factory in Katrineholm, Sweden

Flexible production of system elements for the cost-effective construction of apartments for letting

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With 11,000 staff and an annual turnover of two billion euro, Peab AB, Helsingborg, Sweden, is one of the largest construction companies in Scandinavia. Their geographical market includes Sweden, Norway and Finland. With rents being so high, the company set itself the objective of constructing good quality, multi-storey residential buildings at an acceptable cost.

To carry this out, the basic elements had to be standardised, thus reducing the cost of the elements and of assembly work. Other advantages are the high quality of the products and the possibility of construction with a variety of architectures and designs.

Production hall

According to statistics, the European country with the least number of dwellings standing empty i.e. 0.9 per 1,000 inhabitants, is Sweden. The main reason for this is that citizens with average incomes cannot afford the rent for a new flat and rented flats at affordable prices generally are in short supply.

So far, each construction division of Peab has been using its own methods and designs for multi-storey buildings. Because of the situation, it has been difficult to reduce the costs. The subsidiary, Skandinaviska Byggelement AB, was therefore founded to overcome this problem. One of the major tasks facing this company was to develop and build a new production plant for precast concrete components such as solid walls as well as semi-finished components such as slabs and double walls. Based on the calculated costs of transport to the main area of the sales market, Katrineholm in Sweden was selected as the location for the new plant.

The site was handed over in December 2001 and construction work started in September 2002. Working in collaboration with Christian Prilhofer Consulting, Freilassing, Germany and the engineering suppliers, the first pallet was produced on 3rd September 2003.

Plant requirements

The first step involved a collaboration between Skandinaviska Byggelement AB (SBE) and Christian Prilhofer Consulting to determine the basic requirements for the plant. In order to do this, SBE carried out studies on the current market situation and deter-

Shuttering robot and magazine robot during startup

mined the objectives of Peab AB. At the same time, numerous visits and study trips to reference customers of Christian Prilhofer Consulting highlighted the initial solutions and works designs which were already in existence and these, in turn, led to new requirements on the part of SBE.

Based on this fundamental research, Prilhofer Consulting developed a plant layout designed to implement the basic requirements in the best way possible. The problem of location also had to be considered since, at the beginning of the development process, it was still not certain whether a new works needed to be built, or whether SBE should use an existing production facility.

As a result, a plant layout emerged using a basic concept which had already been proved successful in terms of efficiency in several other plants and, with a few extra features, also fulfilled all the additional requirements.

Scope of production

The plant mainly produces filigree floor slab elements and double walls but also makes solid walls and solid floors as well. Sandwich elements can also be produced. In principle, the company can produce all the products in any quantity and combination but, in some cases, this can lead to slight losses in efficiency. However, this situation can be avoided by appropriate production planning. In principle, the plant can manufacture all the products at maximum efficiency using the plant technology which is currently available – one of the most important requirements stipulated by SBE to enable it to respond to any future developments at the market.

It therefore makes no difference to SBE whether the double wall, as a relatively new product in Sweden, or the solid wall eventually gains the upper hand in the market in future years.

The company is gaining a crucial competition advantage by the dimensions of the element which it can produce – double walls up to 3.60 meters high, solid wall elements up to 3.20 m high and elements lengths up to 13 m.

Plant design

A new three-aisled hall covering approximately 8,000 m² was constructed to house the production plant. The pallet circulation plant takes up two aisles of the hall and the hall aisle containing the hardening chamber and the rack-operating equipment has a clearance of 14.5 m. The third hall aisle houses the mesh welding plant and the lattice-girder preparation plant.

The pallet circulation plant consists of two interlooped circuits. In order to eliminate machine waiting times at pallet changes, the most important machines such as shuttering robot and concrete spreader can operate on two pallet stations in parallel. The demoulding area for slabs is decoupled from the demoulding area for the wall elements so that products can be re-

Manual shuttering stations

Mesh welding plant and reinforcement mesh store

moved from both areas with maximum efficiency and without mutual interference.

The production sequence

Pallet types

The pallet circulation plant operates with three different types of pallet. Each pallet is provided with fixed, tilt-joint edge formwork. Except for this fixed edge formwork, the first type of pallet does not have any other formwork structure. It is predominantly used for solid-wall production or for the second shell of double walls. However, it can also be used as a spare for the double wall with the first shell or for slabs.

The second type of pallet has a second fixed-edge formwork also with a 3.60 m shell on the opposite side to the tilting joint. This type of pallet is predominantly used for the primary shell of the double wall but is also suitable as spare for solid walls. The third type of pallet has a 2.40 m wide, fixed-edge formwork and is used exclusively for the slab production. The precise, right-angled edge formwork made from flexible spring steel to make the lifting of slabs easier can be converted to either the first or second type of pallet by removing the tension arms and moving the formwork back. Thus, the available formwork area can be easily adapted to the different relative numbers of the different products.

Cleaning / oiling / plotting

After the elements have been removed along with the formwork and magnets, the contaminated pallet is moved through a stationary cleaner and oiler. A conveyor belt system transports any concrete remnants from the hall into a container. The next pallet station has a stationary plotter installed above. The whole unit is arranged below the intermediate platform for manual shuttering and is accessible.
On this pallet station, a new production unit is assigned to the inactive pallet – according to the production queue in the master computer and the type of pallet provided. The plotter applies all geometries which the shuttering robot is unable to follow and marks the position of the recesses and fittings. The plotter is also equipped with a second plotting colour. This colour is used to mark the position of the lightweight walls for the interior work of the room on the underneath of the slabs and is visible on the element even after hardening.

Shuttering robot / magazine robot

After the plotter has finished its work, the pallet is transported into the area of the shuttering robot, lifted on to one of the two free stations and presented to the shuttering robot for processing. After leaving the cleaning line, the formwork profiles are supplied via a cyclic cross conveyer.

Between the two pallet stations in the shuttering robot there is a shuttering magazine for the filigree elements. A shuttering magazine for solid wall formworks operated by robot has also been incorporated above two pallet stations. The formwork is delivered to the magazine robot for solid-wall formworks via its own cleaning line. Communication between magazine robot,

Processing the lattice girders

cyclic cross conveyer and shuttering robot takes place via master computer according to the requirements for the formwork.

The formworks for slabs and double walls are designed as channel profiles and are positioned via the magnet strips placed beforehand by the robot. The solid wall formworks have integrated magnets and the shuttering robot is equipped with a gripper-change over system as a special feature.

The first gripper is used for handling the magnet strips and the channel profiles for slabs and double walls. The second gripper is used exclusively for handling the formworks for the solid precast elements and for activating the magnets after the formworks have been placed.

Compaction stations, concrete spreader and tandem finisher

Reinforcement extension working area

In addition to this, the shuttering robot operates using contact-sensor technology. The robot closes the shifting gap which is needed for formwork placement by moving the formwork profiles lengthways before activating the integrated magnets.

Finishing the placement by hand is therefore no longer necessary. Here, particular importance is attached to robot control and formwork logistics since, when using this procedure, a special sequence of movements for the formwork profiles must be followed.

Formwork extension and special fittings

After the pallet has been processed in the shuttering robot, it arrives at the manual shuttering stations. Here also, the tried-and-tested method of separating the processing level from the transportation level for the pallets has been chosen. This means that the pallet is removed from the roller blocks and suspended in a mezzanine for treatment. The circulation is therefore decoupled from a fixed circuit, since each pallet can be transported to the next free station at will after being processed in the shuttering robot. The usual activities, such as completion of the formwork, attaching the fittings, introducing the recess formworks and spacers for the mesh reinforcement are performed at the shuttering stations.

Reinforcement

The reinforcement for the elements is tailor-made for each element according to CAD data on a mesh welding plant built by Progress, Brixen in Italy. The pallet is lowered from the manual shuttering station and transported to one of three possible transfer stations for the mesh reinforcement. There, an automatic crane with a magnet cross beam loads the complete mesh consignment for all elements on the pallet in one go.

The mesh welding plant communicates with the pallet circulation plant by means of a plant image file. This plant image file is updated after each pallet transport cycle in the circulation plant and enables the mesh welding plant to specify the production sequence according to production plant in the pallet circuit. By checking the plant image file, the mesh welding plant is able to make the mesh reinforcement in the run up to the circuit. A reinforcement-mesh store which can hold up to eight complete pallet consignments serves as a temporary buffer for the prefabricated reinforcement. ▶

After the mesh reinforcement has been automatically transferred, the pallet is taken to the transfer station for the lattice girders and to the afterwork stations for completion of the reinforcement. Pallets with slabs and the first shell for the double wall are transported to the station for transferring the lattice girders. An automatic storage system manages the lattice girders and cuts them according to the CAD data for the individual elements.

The computer for the lattice girder preparation plant also communicates with the pallet circuit via a plant image file. This enables the lattice girders to be pre-trimmed for approximately one pallet consignment. A chain magazine is used for transport to the pallet. Here, the staff can place the lattice girders package-wise on the pallets.

The pallet is then transported to one of two available afterwork stations in order to position the girders accurately and complete the reinforcement. These can also be started at will since the two processing stations are decoupled from the circuit at a mezzanine. The lattice girders are still introduced manually to the circulation pallet at this moment but the plant is prepared in order to re-tool a placement robot for the lattice girders.

Concreting

Concreting is carried out on two pallet stations. Slabs and double walls are concreted automatically. The concrete is delivered via a skip-rail system from the mixing plant, which is also new.

A tandem finisher, which travels on the floor, smoothes the solid components on the two concreting stations. While doing so, the position of the tandem finisher is constantly monitored and corrected by the controller for the concrete spreader in order to prevent the units from colliding. It is possible to concrete on one station and smooth elements on the other station simultaneously. This arrangement increases the operating speed in the concreting area, since the concrete spreader is relieved of the task of having to smooth the elements as well as having to concrete them. As well as the concreting stations, another pallet station is available for afterworking or for installing the insulation for the sandwich elements.

After concreting, the pallets are moved into the curing chamber which is capable of holding 78 pallets. The two towers are temperature and humidity regulated to provide the conditions for the optimum hardening time and concrete quality.

After concreting and finishing, instead of being immediately stowed in the curing chamber, pallets with solid wall elements are first subjected to further processing with a helicopter smoothener on a stable concrete surface in a separate racking system which can hold 6 pallets. This additional racking system is not insulated and serves as a buffer while the elements harden preliminary.

The operator at the concreting station can adjust the plant to a certain hardening time before the pallet with element is released for transport. The helicopter smoothener is arranged on a platform which has been set up on the additional rack. This rack is also served by the rack operating system. After the hardening time set by the operators of the concrete station has elapsed, the pallet is taken from the hardening rack and made available for the helicopter smoothener. After the surface has been finished, the pallet is stored in the hardening chamber for the remainder of the hardening process.

Double wall production

Double wall production is carried out by means of a lifting and turning device using vacuum technology. When the second shell arrives at the concreting station, the first shell pallet is removed from the curing chamber and is presented to a special lifting device for first shell elements. The lifting equipment removes all the elements of the first shell pallet in one go and places them on the lifting and turning device. The lifting and turning device is fitted with a number of vacuum cups so that there are always enough suction cups available to hold all first shell elements securely during the turning process.

When the elements are in place and the vacuum is switched on, the suction-turning frame is raised and turned 180°. The freshly concreted second shell pallet moves under the turned suction-turning frame and the frame lowers itself until the lattice girders of the first shell penetrate the fresh concrete of the second shell. After lowering, the concrete is compacted again by vibration and the finished double wall is stowed in the curing chamber.

The empty first shell pallet is moved on directly to the pallet station for the formwork and magnets to be stripped and then made available again to the circulation system for a new production cycle.

Additional rack with platform and double wall production

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Demoulding area

Taking the elements out of storage

After hardening, the pallets stand ready on the stations for lifting off the elements according to the lists for taking pallets out of storage in the master computer. A lifting unit removes slab elements from the pallet and stacks them on the set-down places for the transport units. Double walls are taken out of the curing chamber on their own track and transported to a tilting station. Here, the pallet is tipped up and the overhead crane stores the wall elements in the transport racks which have been made available for this purpose.

The tilting station functions as an overtaking station. The demoulding area is large enough for a second tilting station to be added at a later date so that wall elements can be taken out of storage simultaneously from two stations. The company is therefore prepared for any future demand in wall elements.

Since with solid elements the formwork must be removed before lifting the elements, the producer set up a separate line for demoulding the solid elements early. Early demoulding takes place without any effect on the slab and wall elements being taken out of storage. The formworks for the solid elements have their own cleaning line. The solid elements are therefore demoulded early and the formwork cleaned independently of the filigree-element formwork being demoulded from the filigree elements, removed and cleaned.

A magazine robot and the cyclic cross conveyer bring the formworks together again. After all the formworks for the solid elements have been taken off the pallet and placed on the cleaning line by special handling equipment, the pallet travels through a tunnel under the demoulding area back to the area of the rack-operating system. From there, the pallet either arrives directly at the tilting station in order for the elements to be lifted off or it will be stored again in the curing chamber.
This demoulding circuit enables early demoulding to take place at a different time to when the elements are lifted off. Thus, it is possible to remove the formwork profiles and return them to the production circuit after a relatively short preliminary hardening time, so the number of formwork profiles necessary is kept low.

Occupational health and industrial safety

High priority has been given to occupational health and industrial safety

in the planning and design phase. Those in charge of the project have optimised the working conditions as much as possible in order to attract qualified personnel for the new production plant. One of the main requirements for this was that the noise level in the plant should be low. Over and above the legally required, time-equivalent maximum noise level of 85 dB(A), SBE stipulated a maximum time-equivalent noise level at the work stations of just 80 dB(A).

This meant that elaborate noise protection measures had to be installed, particularly in the steel-processing area. After the plants had been set up, the first monitoring measurement carried out during the test run showed that the required 80 dB(A) had almost been reached. After adding further insulation material, this noise level had been achieved fully. The shuttering robot was also fitted with noise protection panels on the front although, by and large, the noise level at this unit was no greater than 80 dB(A). However, it was desired to separate the staff at the manual shuttering stations from the noises of the robot to a considerable degree. The combination of measures and the cheerful, well-lit hall help to create a pleasant working environment for the production staff.

Solid element – early demoulding station

To ensure maximum industrial safety for the staff, numerous other, constructive and preventive safety measures have also been implemented. On the one hand, the manual work stations have been separated from the pallet transport systems wherever possible in order to rule out the greatest sources of danger – crushing and shearing between moving pallets and stationary objects. All automated areas are completely enclosed and the necessary openings for pallets to pass through are protected by means of light barriers in a muting circuit. The entire pallet circulation plant is subdivided into nine safety areas which are monitored and made safe individually. The reinforcement production area is also divided into five, individually monitored safety zones.

Palettes passing through – protected by light barriers

Project management

One special challenge was to make sure that project management remained effective, in spite of the involvement of so many equipment companies from Italy to Finland as well as consulting engineers centres which were. The project was therefore coordinated via an Internet platform. This approach shortened the information-flow times, since all the partners in the project had equal access to the project information from anywhere at all times. The essential discussions and expensive journeys were reduced to a minimum and, as a result, the project planning period was minimised.

With this new production plant, Peab AB together with Skandinaviska Byggelement AB, have created all the conditions to get their strived-for lead in

the Swedish precast component production market and to achieve their most important objective – the development of their own systems for creating affordable dwellings of optimal quality. ■

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