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New perspectives and solutions for the production of 3D volumetric precast concrete elements

Modular construction is one of the most trending topics in construction industry, particularly driven by the need to find up-to-date solutions for the rapid construction of living space. Modular construction is associated with short construction times and precise planning in terms of time and investment. It is relevant in the western industries, especially in Asia, but also in developing countries, who want to create affordable and secure living space for their growing population.

The topic is not a completely new one though. In 1967, the Habitat 67 residential complex was opened in the Canadian city of Montreal on the occasion of Expo 67, and consists of 354 room modules that make up 158 residential units for up to 700 residents.

Furthermore, in areas such as prefabricated garages, sanitary cells or transformer stations, the use of volumetric concrete elements has a long history.

Already in the 80s and 90s, the engineering office Reymann Technik, from which Ratec GmbH emerged, designed plants for the production of prefabricated garages, sanitary cells or room modules for residential buildings. There is a large number of suppliers who already provide formwork solutions for volumetric precast concrete elements, while Ratec initially specialized in the field of magnetic formwork technology with innovative new developments.

Initiated by customer requirements and in close collaboration with Reymann Technik's planning department, Ratec's first developments and trials with volumetric formwork for room modules began in the beginning of the century. In connection with the development of the mould design, the concreting process was developed, which later became known as upcrete technology. It gave an answer to the question as to how a room module can be produced in its installation position with outstanding surface quality on all sides. The first prototypes of the room module formwork were created in 2005/2006 at the company headquarters in Hockenheim and were constantly further developed after the first successful tests. "This way we were able to present a working solution very quickly, as a request came from Peru in 2010, where we launched the first complete modular house production with mould solutions from Hockenheim," says Jörg Reymann, Managing Director of Ratec.

In the meantime, the company has responded to current market requirements and significantly expanded its product range in the area of 3D formwork. The portfolio now comprises three different solutions or production approaches for different requirements.
The decisive distinguishing feature are the properties of the inner core of the modular formwork. There are three variations:

1. Fixed conical core
2. "Flying" shrinking core
3. Fixed shrinking core

Depending on the element portfolio and requirements of a client, one of the solutions usually is the option of choice.

Fixed conical core – New mould solution for transformer stations

The simplest option for producing a 3D volumetric element is the use of a fixed inner core with draught angle. However, this variant is suitable only for those elements in which the formation of a wall slope in the element is possible with regards to building standards and static requirements. This is usually the case for example in garage production or the production of transformer stations.

In the fall of 2018, an intelligent formwork solution from Ratec for the manufacture of transformer stations was delivered to a customer in Germany.

The aim of the customer was the modernization of its existing production and the replacement of the existing formwork. For this purpose, a mould was developed, which can cover a large part of the different design variants for two types of transformer stations.

The formwork is designed for the production of transformer stations measuring 2.4 x 2.1 x 2.3 m and 2.9 x 2.1 x 2.3 m (LxWxH). To switch from one type to another, the core and the movable outer panels can be rebuilt to suit the other length.

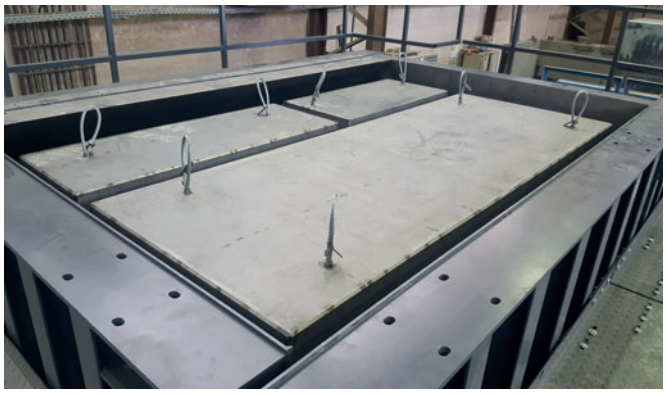

Fig. 1: Different upper parts serve to form the inner walls and the recesses of the element

Fig. 2: Mould for the production of transformer station elements

The different "interiors " of the transformer stations are realized by means of exchangeable upper parts for the core. These are held securely on the core with a hydraulic tensioning device. According to the customer's element program with 14 different variants, there is a total of 23 different upper parts available to produce the different types.

It takes on average about 20 minutes to change the upper parts - a huge time gain compared to the previous production, in which a change could take up to half a day.

Fig. 3: Finished element

The core is provided with the mentioned draught angle for demoulding. To facilitate the demoulding process, the bottom of the mould is raised hydraulically by about 10 cm before the element is lifted off. In addition, the mould is equipped with a vibration unit, which is used when using normal or washed concrete instead of self-compacting concrete.

"Flying" shrinking core - the upcrete principle

The room module formwork with "flying" shrinking core was the first development of a volumetric mould from Hockenheim and was used in the Modular Housing project of a Peruvian customer, which has already been covered several times in this publication.

This mould type is set up for the use in combination with upcrete technology, which means self-compacting concrete is pumped from below into a closed mould. The process allows for optimal spreading of the concrete within the formwork and smooth surfaces on all sides as well as the exact formation of edges and recesses.

Another advantage is the production in installation position, which makes a subsequent turning unnecessary. First, all installations are prepared at the core and the reinforcement is fixed. Only then is the core lifted into the mould and connected to the external walls. After filling and curing the room module in the mould, the core is shrunk and then lifted off first.
In the project in Peru 3,600 houses are built over a period of 60 months, each consisting of three room modules, each with 18 square meters of interior space. Two houses are finished per day. The total production time for a house is about 80 hours - from the first touch to its completion on site.
The decision in favour of Ratec's solution was mainly due to the prospect of the element's high surface quality, as walls can be directly painted without further refinishing. For another project in the Philippines, the upcrete modular mould system was adapted for room modules of the size 5.6 x 2.5 x 2.8 m (LxWxH).

Modular Housing with upcrete is designed for projects with room modules of similar size and pays off over the entire project period by the number of manufactured modules and houses (recommendation:> 600 houses).

Up to 25 sqm large modules can be produced very economically in this way. For larger room dimensions, it will have to be checked whether a pressure filling of the mould is the most sensible method. Also, the special requirements for the concrete quality when using pressure filling by pump are not given in all regions. Based on the elements that a customer wants to produce, they are first analysed, taking into account the framework conditions (production process, region, etc.), and then the most suitable solution for the production of these elements is proposed.

Fixed shrinking core – the mould kit principle

With the intention to offer an adequate solution even for smaller projects with lower production volume, a new mould solution was designed, which a) is suitable for filling from the top and from below, b) guarantees even more flexibility and c) with which also complex details in the element can be realized. The solution developed by Ratec can easily be integrated into existing production facilities thanks to the possibility of conventional filling from the top.

Fig. 4: Flying shrinking core and room module mould in the plant in Peru

A special feature of the new mould development is, on the one hand, the patent-pending shrinking mechanism, in which the core is lifted and shrunk in the same work step. On the other hand, the formwork was intentionally designed following the idea of a flexible mould kit. The core and exterior panels are made up of various standardized parts, that are easy

Fig. 5: New development: Modular 3D mould with fixed shrinking core

to swap and adapt to other room dimensions. As a result, the mould solution can be used economically efficiently even if the production volume of a certain room element type is low.

This new flexible modular 3D mould will be first presented to the public at bauma from 8 – 14 April 2019 in Munich.
The further developments and new solutions for the production of volumetric concrete elements, that were completed last year, are an important step for Ratec towards becoming a specialists in 3D formwork solutions, which are becoming increasingly important alongside magnetic formwork technology.

"We see ourselves as a solution supplier for all types of formwork, which are required for the production of precast concrete components, be it shuttering systems for the production of planar elements, battery moulds or 3D moulds for volumetric precast concrete elements. Thanks to our expertise in all these areas, we are able to recommend and provide the customer with the formwork solution that best suits his needs, "summarizes Andreas Reymann, Managing Director and Head of Engineering at Ratec.
Ratec presents the new modular 3D formwork and other new developments at bauma in Hall B1 at stand no. 348. ■

FURTHER INFORMATION

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