Wasa Compound GmbH & Co. KG, 98617 Neubrunn, Germany

Polyurethane precast moulds for the new Puskás Ferenc Stadium

Following the establishment in 1980 of what at that time was Wasa Unterlagsplatten GmbH, which initially concerned itself with the manufacture and sale of production boards for block making machines, the Wasa Group also successfully began with the production of polyurethane wetcast moulds in 2007. After the company, now renamed Wasa AG, had established itself in the wetcast production sector, the mould manufacturing business field was expanded in 2017 by large form liners. The new Wasa Precast brand was born and will be officially presented to the public at this year's bauma.

With Wasa Precast the company based in Darmstadt and Neubrunn (Thuringia) is capable of casting even very large form liners in high-quality polyurethane. The moulds presented in this report measure an impressive 7 x 2 metres. Another project implemented with Wasa Precast was presented in CPI 06/2018 – the London Crossrail route.

Project

Following the award of the contract in Great Britain, Wasa then also won the contract for part of the cladding of a large football stadium in Budapest – the Puskás Ferenc Stadium. Construction of the new stadium had already begun in 2016. Plans to partly incorporate the old stadium into the new structure were discarded again. The reopening is planned to take place on 25 November 2019. The capacity will be 67,000.
Four matches of the UEFA European Football Championship 2020 will take place in the new stadium. Apart from football matches, the Puskás Stadium will also be available for concerts and conferences. The stadium will be able to accommodate up to 78,000 spectators at such events. Apart from football, other sports can be played at the stadium. It is planned to incorporate rooms for table tennis, gymnastics and wrestling into the grandstands

Task

Within the context of the planning of the new Puskás Ferenc Stadium, the external facades of the 30 staircases are to be given a special surface structure. Wasa was awarded the contract to manufacture the precast moulds required for this. The elements in the form of protruding circular rings that already existed on the demolished staircases served as the template for the new structure. The individual staircases have a width of about 7.50 m and a height of about 30.00 m. The requirement was to clad the exterior façade with 13 precast concrete elements, each measuring 2.20 m x 7.00 m x 0.24 m.

In order to minimise the assembly work and to make the precast concrete elements as stable as possible, a solution was sought in which the circular rings are integrated in the precast concrete element. The connection of the individual elements is then to be implemented with separate circular rings, as a result of which the separating lines of the concrete elements are reduced in appearance. A possibility also had to be found of individually compensating the dimensional tolerances of the exterior stringers in both width and height on site. On account of the complex requirements, a solution was chosen for the manufacture of the concrete elements using flexible polyurethane moulds such as are already used successfully in wetcast production. The unusual feature of this application was the required dimensions of the PU moulds, which led to a mould weight of around 1,800 kg and thus presented Wasa with the most diverse challenges as regards model construction, raw materials and handling, taking into account the estimated budget.

Manufacture of the model and the PU mould

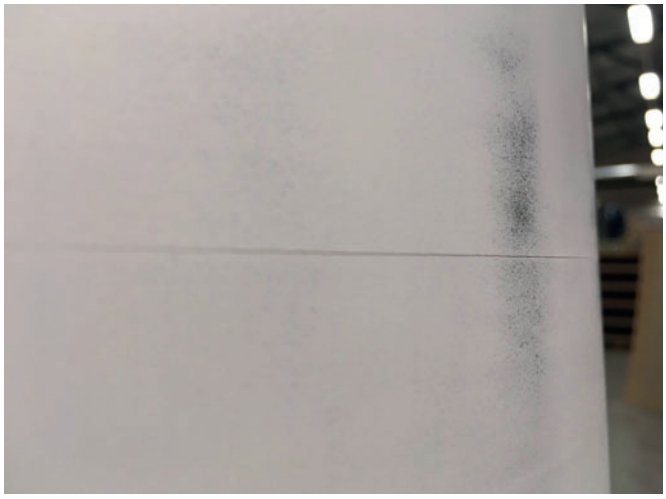
One of the first decisions to be taken for the implementation of the project was the selection of the raw materials for the model construction and the PU moulds.

During the design of PU moulds one can directly influence the overall mass and the vast majority of the manufacturing costs of the PU mould through the geometry and design of the wall thicknesses as well as the use of displacers, whereas the geometry of the model is dictated by that of the precast concrete element. An optimisation of the model manufacturing costs was only possible through an appropriate choice of material, taking into account the resulting processing expenditure.

Model construction

After the careful weighing up of all the pros and cons during discussions between the client and WASA, the choice of raw material for the model of the casting mould fell on multi-layer wood. The advantages and disadvantages of multi-layer wood are as follows:

Model during processing on the 5-axis CNC milling machine



Hairline cracks in the model body

Finished wooden model on the casting table

Advantages

- low raw material costs
- fast availability
- manufacture of targeted contours through the bonding of pre-sawn board pieces
- simple processability during milling
- short milling times due to high feeding speeds
- tried-and-tested application in the manufacture of large-volume models
- sustainable raw material

Disadvantages

- tendency to form hairline cracks in case of temperature fluctuations
- complex reworking to achieve the necessary surface quality
- gas formation in the PU on contact with hairline cracks
- risk of faults in the bonding

PU dosing system with vacuum storage tanks

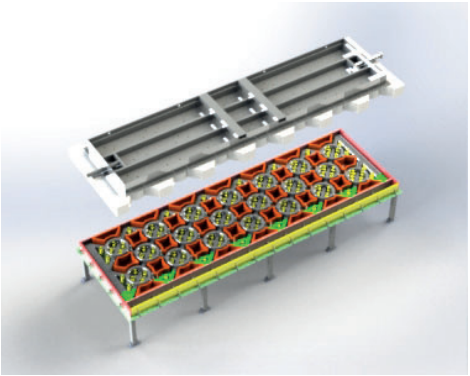
PU system

To avoid a possible faulty casting and the associated high costs, the PU system was specially developed for use on the wooden model together with one of the leading system suppliers of casting resins. On account of the quantity of casting resin required, a system with a correspondingly long pot life was needed. Also, the mould was to be cast in several layers and the individual layers had to bond to one another without visible contours. A further requirement for the casting system was the physical shrinkage, which had to be as low as possible due to the seven-metre length of the model. Also, a non-filled system was to be used so as to avoid changes in the PU mould during the concreting work. Last of all, the viscosity of the casting resin had to be adjusted so that an even level and thus optimum filling of the individual ring cavities could be guaranteed. All the properties had to be analysed in advance and tested in practice on a sample mould. A new dosing system with a delivery capacity of 22 kg/min was specially acquired for the casting of the mould so that the mould could actually be filled within the set pot life.

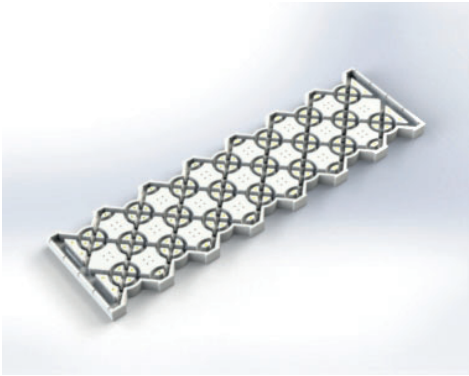
Casting table

On account of the large number of displacers and steel anchors in the casting mould, Wasa's in-house locksmith's shop manufactured a special steel frame so that assembly work could also be carried out underneath the model. A mobile work frame was installed above the model, as a result of which every point on the model was easily reachable without directly contacting the model. This was a prerequisite, as all surfaces had to be treated carefully and reliably with a release agent prior to pouring the casting resin. Even the tiniest fault in the release layer would inevitably damage the mould and the model and lead to a faulty casting of the PU mould. Wasa was helped in all of these structural measures by its double-nave hall with a floor area of 2,400 m^2, which was only completed a year ago and without which the handling of such large moulds would not have been possible.

David Werning (project manager) and Dr. Arno Schimpf (managing director) at the building site in Budapest.



Steel subframe with the casting model and displacers, plus the upper part with the PU mould



Polyurethane mould

Demoulding fixture

The separation of the PU mould from the casting model also represented a particular challenge. Hence, a special aeration valve was attached to each circular cavity in order to release the vacuum and the adhesive forces between the polyurethane and the very smooth surface of the model. To do this, all displacers and cores were first removed using a special pulling jig and a steel plate was then bolted to the PU mould. Now the polyurethane had to be released evenly from the individual cavities and the frame with the casting mould lifted in a plane parallel position by a crane. This process requires the utmost precision, as the tiniest amount of skew will lead to the PU mould jamming in the model, preventing demoulding.

Precast concrete element

The fundamental requirements for the surface of the exterior skin of the staircases arose firstly on the basis of the preceding structure of the old stadium and secondly out of the necessity to ensure the most interference-free possible transmission of radio, television and mobile phone signals both into and out of the stadium.

Through the use of a highly flexible PU mould it was possible to manufacture a glass-fibre reinforced precast concrete element with precisely this structure and a high rigidity. The tolerances to the lateral stringers as well as to the upper and lower retaining elements of the staircases were compensated by individual inserts in the PU moulds. To this end the respective staircase was measured prior to production and the spacers were then placed inside the mould accordingly. This resulted in precisely fitting individual elements that can be integrated almost seamlessly into the staircases. The joints between them were covered by concrete rings that also bond the concrete elements together. The appearance of the stadium was thus decisively shaped by the architecture of the staircases through the interaction of flexible moulds and high-performance concrete.

Summary

With complex projects such as the construction of the Puskás Ferenc Stadium, the implementation of slender, but very strong exterior facades quickly reaches its limits without the use of appropriate PU moulds. A flexible casting mould is indispensable, especially from the point of view of existing undercuts.

Thanks to the use of BIM building models the necessary data sets for the mould construction are normally instantly available, allowing the special features of the required moulds to be implemented very quickly. In this example the implementation took only three months from the enquiry to the delivery of the PU moulds.

Wasa has achieved an absolute highlight in the precast industry with this project. When four matches of the UEFA European Football Championship take place in the new Puskás Ferenc Stadium in 2020, all Wasa employees will be paying attention not only to the football match itself, but also to the exterior façade of the stadium. ■

FURTHER INFORMATION

WASA Compound GmbH & Co. KG
Meininger Straße 9, 98617 Neubrunn, Germany
T +49 36947 5670, F +49 36947 56721
wetcast@wasa-technologies.com, www.wasa-wetcast.com