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Solution-oriented system of formwork and liners for flat concrete elements

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Solution-oriented system of formwork and liners for flat concrete elements

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Ambitious architecture for modern facades is hardly possible without the building material concrete. The shell of a building is evolving from the classic in-situ concrete formwork to prefabricated and individual precast concrete elements. In order to realise a vision of architects and planners, the demands on the concrete worker arise right from the start of a project with the design of a suitable casting mould or formwork. In order to meet these requirements, Wasa offers a comprehensive service ranging from virtual 3D models to individually manufactured casting moulds.

Universally applicable longitudinal and transverse shuttering profile system for all flat precast concrete elements

In a collaboration between the Steinbeis Innovation Center FiberCrete and Wasa Compound GmbH & Co KG, the modular shuttering system, Wasa Shuttering, was developed. For Wasa Shuttering, wood-based panels made of European spruce veneer are coated with polyurethane in Shore A65. The edges of the wooden beams are also coated with the flexible polyurethane and thus give the production table a laminar seal. Wasa Shuttering is supplied with a standard chamfer at the factory to produce smooth and clean edges on concrete blocks. Extensive silicone work to seal the formwork and form the chamfers is therefore not necessary. The highly wear-resistant polyurethane coating on the concreting and edge side reduces the wood swelling of the veneer layers used and thus increases the service life of the formwork.

Design structure of a modular form

In order to produce a form for the modular adjustment of different geometric dimensions of concrete blocks, the use of a

Fig. 1: 7.0 m long model and casting mould for curtain wall elements (GFRC), Neuer Kanzlerplatz, Bonn, Germany

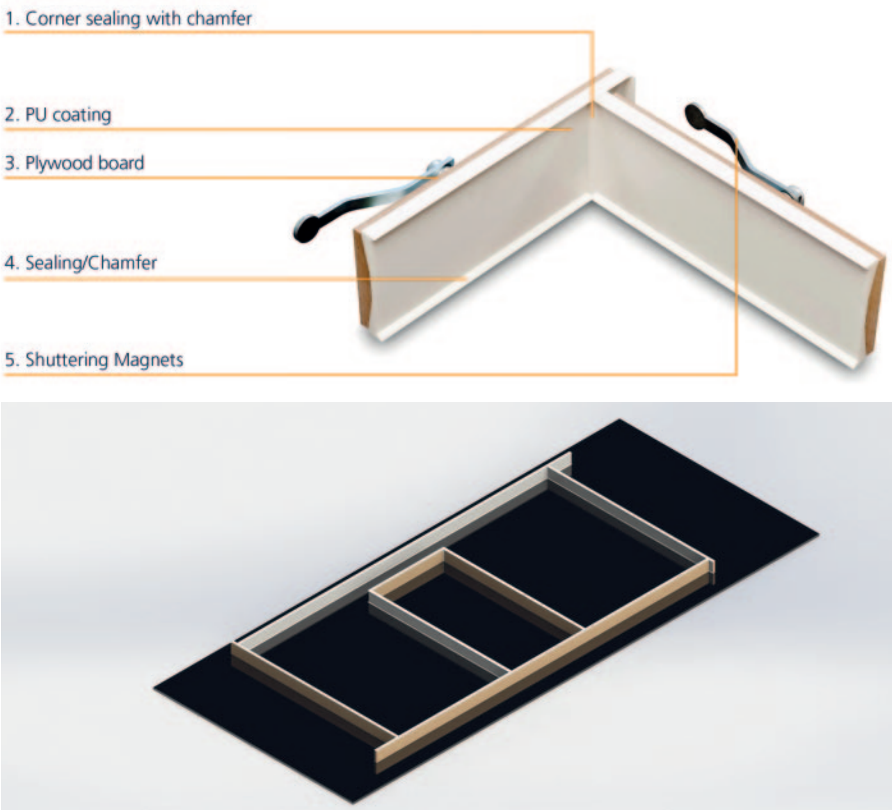


Fig. 2: the shuttering profiles allow modular adjustment of different dimensions

large number of elements is purposeful. In this case, shuttering profiles, which consist of a plywood board and a cast-on polyurethane, act as edge elements (Fig. 2). These can be fixed to a magnetic formwork surface, e.g. steel, by one or more shuttering magnets screwed onto it, depending on the overall length of the shuttering profile. The shuttering profiles are positioned with the front face against the inside so that they can be moved towards each other. The system automatically seals itself by means of a sealing / chamfer, which is provided on the one hand on the front face and on the other hand on the inner side of the shuttering profile. Due to this positioning principle, concrete elements of any width and length can be produced with the shuttering profiles.

Due to the different possible heights of the shuttering profile system, concrete elements up to 360 mm thick can be realised. Furthermore, different chamfers and shapes can be implemented according to customer requirements.

Fig. 3: Filigree facade cladding, the individual elements vertically and horizontally are manufactured in formworks (Fig. 1) made of glass fibre reinforced concrete, Lindner Group project, Neuer Kanzlerplatz, Bonn, Germany

Fibre-reinforced PU liner for textured and flat precast concrete elements

Material and technology development

The integration of structured inserts requires minimising the thickness of the material without increasing the risk of damaging the inserts after a small number of impressions. For this reason, a fibre reinforcement of the applied polyurethane was developed, which was tested with different types of fibres with regard to the slump-flow and the homogeneity of the mixed composite (Tab. 1).

Tab. 1: Slump-flow and homogeneity of fibre-reinforced PU mixtures

Type of fibre	Fibre content in % by volume	Slump-flow in cm	Homogeneity
Without fibres	0.00	35	high
Alkali-resistant glass fibres 0.75	0.75	34	high
Alkali-resistant glass fibres 2.00	2.00	31	medium
Screed glass fibres (Screed-glass)	1.50	33	small
Basalt fibres	2.50	34	small
Polypropylene fibres 0.30	0.30	34	high
Polypropylene fibres 1.00	1.00	31	high
Polyvinyl alcohol microfibre	2.50	34	small
Carbon fibres (dispersible)	0.50	31	medium

The objectives of fibre integration were to achieve the highest possible fibre volume content with a homogeneous mixture (Fig. 4), which shows a similarly high flowability as the non-reinforced PU mixture (35 cm).
Although the mixtures with screed glass fibres, basalt and polyvinyl alcohol microfibres showed a high slump-flow of 33 and 34 cm respectively at a fibre content between 1.50 and 2.50 percent by volume (Tab. 1), there was segregation between short fibres and PU matrix (Fig. 4c).

Due to the high homogeneity as well as the high slump-flow of the PU fibre mixture when using the alkali-resistant glass fibres and the polypropylene fibres, these were selected for subsequent test methods. Rectangular test specimens with a cast-in section were made from the corresponding mixtures. The fibres were mixed into the hardener in the corresponding proportions (0.3 – 2.0 % by volume) before mixing the components and tested for the tear propagation resistance of the cut after hardening (see Fig. 5)

A selection of the test results on tear propagation resistance is shown in Fig. 6. All displayed fibre reinforcements showed an increased tear propagation resistance compared to the fibre-free test specimens. The PU with 2.00% by volume of reinforced alkali-resistant glass fibres and 1.00% by volume of

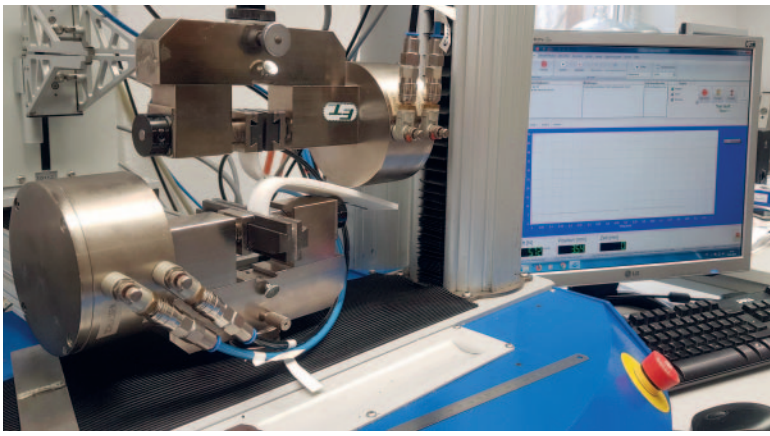
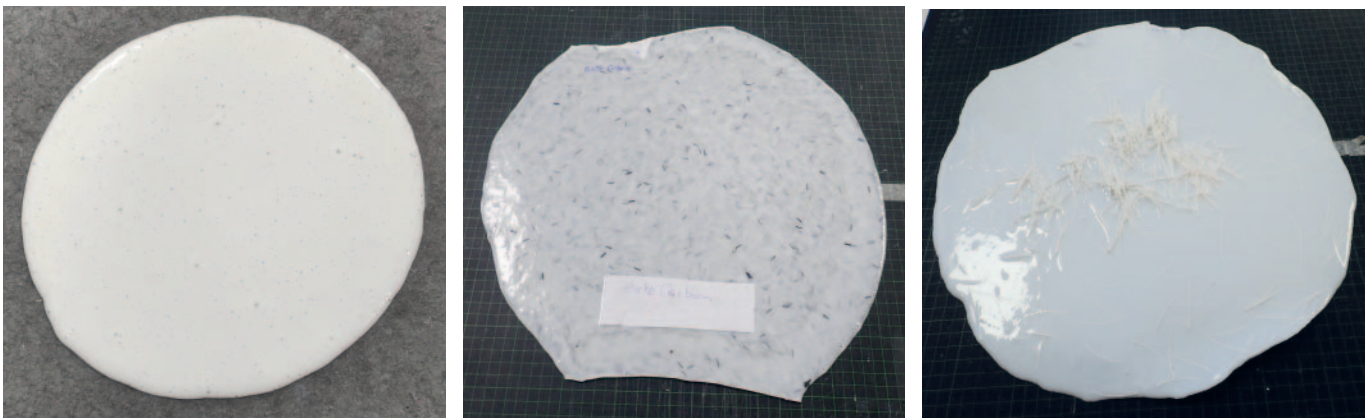


Fig. 5: Test set-up for testing the tear propagation resistance



(a) Polypropylene fibre

(b) Carbon fibre

(c) Polyvinyl alcohol microfibre

Fig. 4: Exemplary slump-flows of homogeneous [(a) and (b)] and inhomogeneous fibre-reinforced PU mixtures (c)

reinforced polypropylene fibres had the highest tear propagation resistance of 56 N and 36 N respectively, which increased the tear propagation resistance by 280% and 180% compared to the fibre-free PU (20 N). Due to the better handling, the polypropylene fibre was selected for the production of a textured insert.

By increasing the tear propagation resistance, it is possible to minimise the thickness of the insert, which considerably supports the use of Wasa Shuttering.

Preparation and testing of test specimens

To verify the functionality of the fibre-integrated structural insert in combination with the Wasa Shuttering system, the tree bark surface texture was produced both by Wasa Compound GmbH & Co KG and in the laboratory of the Steinbeis Innovation Centre FiberCrete. The production of the test insert with the dimensions 1800 x 800 x 3 mm³ included the mixing of a homogeneous polyurethane fibre mixture with 1.00 % by volume of polypropylene fibres (Fig. 7).

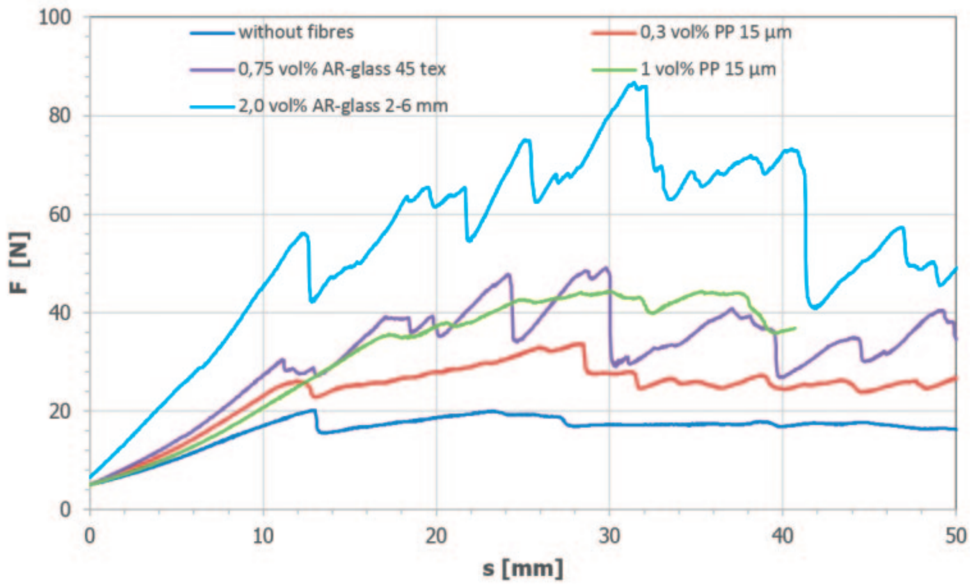
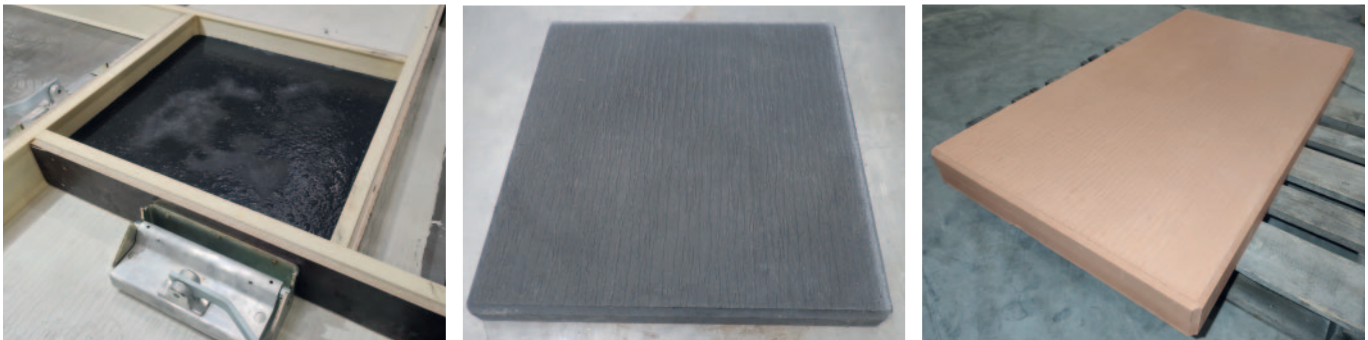


Fig. 6: Results on tear propagation resistance

(a) Polypropylene fibre

(b) Fibre-reinforced tree bark textured insert

Fig. 7: Freshly moulded insert made of Wasa Pur reinforced with polypropylene fibre



(a) Cast concrete element

(b) SCC (600 x 600 x 60 mm³)

(c) SCC (1200 x 700 x 100 mm³)

Fig. 8: Concrete blocks freshly cast (a) and demoulded [(b) and (c)]

The fibre-reinforced insert was able to be demoulded after 24 hours. The insert was held in position by the magnetic closure system of the shuttering profiles and then integrated into the Wasa Shuttering System. Both formwork-smooth and textured precast concrete elements made of self-compacting (SCC) and plastic concrete were produced. Fig. 8 shows a selection of the results in the dimensions 600 x 600 x 60 mm^3 (left and centre) and 1,200 x 700 x 100 mm ^{3} (Fig. 8, right). The test specimens showed a very high surface quality and were able to be demoulded without any problems or damage to the shuttering profile system and the insert.

Tests for the production of precast elements with different textures and sizes have proven the modular functionality of the developed Wasa Shuttering System in combination with fibre-reinforced textured PU inserts. The particular advantages of the system are the free choice of dimensions and the resulting possibility of implementing a wide variety of applications, from palisades and terrace slabs to precast concrete slabs, with one system and the enormous savings potential in individual mould making that this offers.

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FURTHER INFORMATION

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