

UHPC Applications Overview For Architectural Cladding Elements In the Precast Industry

Anais Aymont (corresponding author) – Business Engineer Smart-Up, VICAT, L’Isle d’Abeau, FR, Email: anais.aymont@vicat.fr

Jérôme Frécon – Department Manager Smart-Up, VICAT, L’isle d’Abeau, FR, Email: jerome.frecon@vicat.fr

Abstract

For new or renovated buildings, UHPC is used in architectural applications. Conceptions are multiple: cladding panels, sunshades, meshes, awning roofs, etc. Thanks to the finesse of UHPC, complex shapes can be produced with specific dies and colors while working with low thicknesses.

There are many examples, such as Roquefavour slabs (France) with a stone-effect matrix; the awning roof of the Villa Vertigo (Ramatuelle, France) with a around 7 x 11 m (23 x 36 ft) cantilever; the sunshades of the communal building (Etterbeek, Belgium) or the mesh cladding of Flon facade (Lausanne, Switzerland).



Figure 1 : Slabs

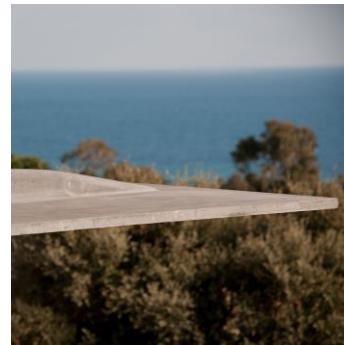


Figure 2 : Awning Roof



Figure 3 : Sunshades

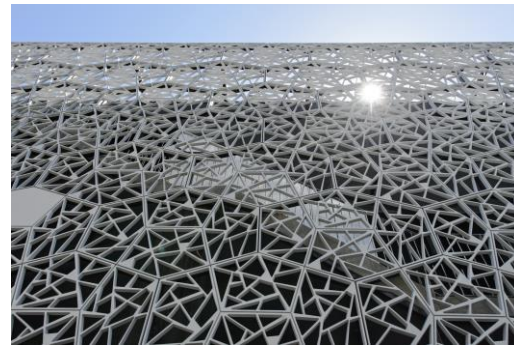


Figure 4 : Mesh cladding

Thanks to the significant mechanical characteristics of this material, passive reinforcements can be removed or greatly reduced compared to the traditional concrete. This simplifies the manufacturing part and also reduces the weight of the elements which become easily movable.

Durability characteristics give elements a lifetime of at least 100 years depending on exposure classes. All the characteristics of UHPC also provide an impact and seismic protection.

The most developed architectural part in Europe, characterized and standardized based on French standards, is the cladding with invisible fixings. The installation of 2 cm (0.79 in) thick panels can be carried out on a load-bearing structure in masonry, concrete or on construction with a wooden frame. The chassis is made of aluminum with an anchoring system adjusted for thin plates. These small inserts have a useful length of 1 cm (0.39 in) and a diameter of 6 mm (0.24 in), but many more inserts exist for cladding applications.

Keywords: UHPC, Cladding, architecture, sunshade, mesh facade, cantilever roof, anchor system

1. Presentation of UHPC Cladding

A cladding is the exterior aesthetic layer of a facade, generally made of wood, metal or composite materials, such as concrete. We would like to introduce you to UHPC cladding, Ultra-High Performance fiber Concrete and its various advantages. The UHPC cladding makes it possible to dress the urban landscape with an aesthetic facing. The fineness and the strength of the UHPC material free the creativity of architects with unlimited conceptions made up of complex shapes, ultra-fine textures, invisible anchors, and a wide choice of colors. The high durability of this material, which ensures a longevity, and its low maintenance allow a significant long-term economic gain.

2. Characteristics and Production

2.1. Characteristics

The cladding elements are made of UHPC for their durability and aesthetics.

The durability of a UHPC over time is around 100 to 150 years minimum thanks to its low porosity. This parameter also makes it resistant to chemical attacks. The material is also incombustible and impact resistant. In addition to these intrinsic advantages, it is maintenance-free. All these advantages place UHPC well ahead of other solutions in terms of durability.

In addition, the mechanical characteristics, ranging from 110 to 150 MPa in compression and 4 to 8 MPa in post-cracking resistance, make it possible to significantly reduce the thicknesses of the elements compared to conventional concrete and to dispense with passive reinforcement. The elements are lighter, which facilitates their installation.

2.2. Choice of Product and Fixing Insert

The formulas are based on the type of premix for the color, and fiber type for performance and applications.

In terms of color, UHPC are available in grey or white depending on which cementitious base is used. Moreover, mineral pigments can be added in the mix to create a specific color.

Then the choice of fibers is defined according to the mechanical characteristics. The fibers are metallic or organic for the grey bases and stainless steel or organic for the white bases. For

architectonic applications, UHPC are mainly used in white with organic fibers. One of the most efficient organic fibers, which has been on the market for many years, is a PVA fiber, PolyVinyl Alcohol. New fibers are being developed such as the Aranea fiber, from Michelin group, based on CGR technology, Composite Glass Resin or the Concrix fiber, from Contec fiber, in PP, PolyPropylene. If the mechanical performance specified by the customer cannot be achieved with organic fibers, the use of stainless-steel fibers is needed. This makes it possible to produce external surface without having any risk of rust on the light elements.

The cladding is rig up with invisible fixing. Initially, the anchoring systems used for UHPC cladding applications were based on natural stone systems: a groove in the panel which clings to the facade via a clip. This technology was not ideal for claddings's application. Thus, new inserts have been developed to allow a very high load capacity to be taken up. This is possible thanks to a homogeneous load distribution, without overloading the front panel with a minimum thickness of around ten millimeters. The most used for years is the KEIL insert. In the factory or on site, holes are drilled using CNC, Computer Numerical Control, or portable machines after the panels are manufactured. The perforation is carried out under water, which can cause marks on the parts. Another type of inserts, NEEL, allows to install them during casting for immediate and permanent fixation. This permits the inserts to be used as lifting tools for precasted parts. The Fixinox inserts and the Gardette interscrews are also technologies implemented when the panel is poured.

2.3. Production

The production of these elements is carried out in the factory.

The first step is the mold's conception. On the one hand, they can be dedicated to a project that minimizes the volume of UHPC consumed. On the other hand, molds can be generic and reusable for different projects, but the panels must be cut under water after. In this case, the layout of the project must be as optimized as possible for the production tool. The molds can be made in metal, polymer, wood, or even with a 3D printer. As UHPC is a material with a very small grain size, the casted element will be a perfect impression of the mold matrix. To ensure a good finish, the matrix must be perfectly prepared before casting. The use of an unsuitable demolding product incorrectly applied or in large quantities will cause surface defects (traces, bubbling, etc.).

After completion, it is important to protect the elements with a waterproofing product from the risk of efflorescence: migration of mineral elements which crystallize on the surface. These phenomena can create visual disturbances. In addition, project specifications generally require an anti-graffiti product.

2.4. Technical Advice

The UHPC standard, from 130 MPa, allows the designer to size projects according to Eurocode standards. Classic architectural applications with lower performance (110 MPa cladding type) are not covered by the UHPC standards. For these elements, Technical Advice are carried out in order to obtain market insurance. The Technical Advice procedure is checked by an independent organization to control the systems through tests and have them certified by a scientific committee. The 20 mm cladding panels were the subject of Technical Notice No. ATEx 3107-V1 to be marketed without additional study. The tests carried out are the characterization of the material as well as system tests with seismic tests, impact resistance tests and wind resistance tests.

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