An interview with Oliver Tessin in Architektur + Technik

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Historical with a digital extension.

From Morris Breunig

The Deutsches Museum in Munich is reinventing itself and combining historical building fabric with future-oriented technologies. The temporary main entrance of the redevelopment object presents itself as an optical eye-catcher, whose digital innovation can be found in the use of computational design methods for 3-D printed façade panels and completely recyclable plastic (PETg). The underlying computer-based design process developed by 3F Studio offers the potential for performative design beyond the project. Oliver Tessin, one of the three founders of the start-up, 3F Studio, is responsible for the computational design methods and describes the processes and the challenges involved in an interview.

What purpose does the temporary façade at the Deutsches Museum in Munich serve?

The 3-D print façade is the thermal shell of the temporary main entrance and at the same time the pilot project for the multifunctional 3-D print façade application developed by us, 3F Studio. 3F Studio is a spin-off of the TU Munich, which I founded together with Moritz Mungenast and Luc Morroni. Ideally, the façade, as described by the Deutsches Museum as the "Gateway to the Future", should be visible as a beacon for the initiative "On to New Worlds" in the city of Munich and should also stand for innovative progress in the state of Bavaria.

Which planning method was used for the project?

To understand the method and the potential of the facade application, the approach must be explained. Building has always been significantly influenced by new technologies - for example, with the aim of designing more intelligently and using less material. I believe that mass-computation and 3-D printing will have a relevant influence on the future of building. And in order to make sound use of this potential, I am systematically focusing on two criteria: high resolutions and geometric complexity, as is the case with the design principles of nature. I think this is crucial for developing morphological systems and sustainable material strategies that make informed use of current technological progress. Already the architects of the Gothic period derived methods for finding forms from nature. The pressure-based load-bearing structures of Gothic cathedrals were built larger, more filigree and with more efficient use of materials than was possible with the construction processes commonly used at the time, and this was done using only geometrically simple blocks of material. 3-D printing makes it possible to build computer-optimized and thus highly complex geometries with the resolution of a grain of sand, which were previously impossible to realize. In my opinion, this enables a new quality of consistency between form and material (function), which provides food for thought. Because visual (form) and constructive (function) aesthetics are inseparably "fused" into one unit. I have condensed this approach in "Fused Form and Function" - hence 3F. These planning methods and processes developed with it made it possible to algorithmically replicate the soft folding at the Deutsches Museum. By increasing the resolution and complexity of the façade surface, we were able to enrich the design process with a variety of functions such as shading. The folding has a significant influence on the characteristic design and, due to its own shading, enables the energy input to be adapted adaptively to the building use and location with regard to the course of the sun. Other functions such as lighting, insulation and thermal ventilation could also be solved locally and geometrically. The result of the morphological material system is emergent the sum of these functional requirements. The facade generated in this way is tailored to the project and potentially applicable to any location worldwide. "Fluid Morphology", as we call the facade application, is the result of the research-oriented 3D Envelopes studio at the Chair of Design and Building Envelopes at the Technical University of Munich. It is based on Moritz Mungenast's doctoral thesis on multifunctional 3D printed facade panels and on my shape studies on parametrically soft folded surfaces.

> "The classical education of the architect is extended by computational methods."
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> Oliver Tessin

Is computational design an advance?

This can be easily explained by comparing it to computerization. A computerized process such as CAD (computer-aided design) streamlines complex design processes. The results are usually geometrically simple shapes that make elaborate planning and production processes more efficient - no architect draws plans or plans cost-effectively in pencil. Computational Design reverses this process. Mass-computation makes it possible to take into account functional requirements and morphological material properties - 3D-printed PETg - with a precision that the resulting geometry is literally shaped by the action, for example the course of the sun. This means that architectural problems are no longer solved with predefined shapes. Computational design methods not only enable architecture with tailor-made performance, design and low material consumption, but they also provoke a rethink for our built environment - our resources for building materials are finite and our cities are growing fast.

How are the results achieved?

Let's take the example of folded surfaces. The first step is the location analysis. We look at the building orientation and at which time of the day shade should be applied. The morphological system or script uses this data basis, for example statistical weather data, to generate the geometry. The system is programmed in such a way that the available morphospace of the 3-D printer (Fused Deposition Modeling) as well as the malleable material properties of plastic are fully taken into account and only solutions that can actually be produced are generated. With this process sequence, countless possible geometries are generated, whose thermal performance is simulated. During the process an evolutionary algorithm continuously adjusts the parameters for geometry generation - for example convolution angle - in order to generate the ideal geometry according to the defined objective functions, in this case lowest energy input.

Does this make classical design planning obsolete?

No. It will always be the architect or the designer who operates the computer. Computational design methods, however, make use of significantly more computer capabilities than just CAD drawing programs. Here, in conjunction with the impulses mentioned above, a rethink is provoked. This is because in Computational Design Thinking, architects design tools that clearly exceed the computing capacity and precision of the human brain and take into account any requirements and planning specifications in order to generate the best solution. As happened a few decades ago with CAD tools, the classical education of the architect is already being expanded to include computational methods.

Does this make classical design planning obsolete?

The step towards implementing morphological systems in BIM components is still a long way off - as is the potential hidden in them. Automation is already part of BIM, for example, to generate door lists. Because the applied computational design process is not yet standard in practice, BIM was not part of the planning for the Deutsches Museum. However, the digital design process we developed for the façade forms the basis from which BIM components can be programmed in the future. Other planners will then be able to use these design processes in BIM software and potentially send production data directly to the 3D printer.

And 3-D printing rounds off the chain of benefits?

3D printing makes the complex digital shapes possible in the first place and closes the "digital chain".

Will 3-D printing significantly change the way we build?

This is a question we and our faculty at universities are intensively dealing with. How can new technologies be used in a well-founded way in the design and construction process? One of the most tangible arguments for change is that 3D printing allows components to be manufactured additively - virtually without material waste. The problem of building material waste is self-explanatory. Just like the components used in the building, they are usually only down-recycled. The plastic of the 3D-printed façade at the Deutsches Museum allows it to be reused three to four times. We are planning the material used here for future projects in order to create a closed material cycle. 3-D printing with concrete also opens up possibilities with low material consumption and production waste. I believe the influence will be great - even on a small scale and in relation to interiors or pavilion structures.

What are the design challenges?

For the façade, we have primarily investigated building physics issues - and also developed solutions. In terms of construction, our application is a curtain wall system. We plan a conventional substructure with experienced facade manufacturers. Several segments (one metre by one metre) are prefabricated as storey-high curtain panels and hung on site - there is no difference to the usual installation procedure. However, the integration of conventional substructure profiles and suction anchors into the 3-D pressure components is adapted to the actual load in the component in a form-adaptive manner. These are not visible from the outside. The plastic expansion of six millimetres per one metre should not be underestimated. However, we have taken this into account in the tongue and groove connection of the panels, which also serves as the necessary silicone joint. The joint pattern was used for design purposes. We have already taken into account the aforementioned building physics approval conditions such as pressure and suction forces, fire protection and UV resistance. We are also making great leaps forward in terms of financing.

Are manufacturing and assembly considered in the design process?

Digital fabrication - in this case additive manufacturing - is integrated into the design process at an early stage. Just like material strategies and design principles known from nature, the 3D printing process stimulates completely new solutions. The parallel integration of computer, digital fabrication and design principles into one process is crucial for the performance of the morphological system - in this case the facade application for "Fluid Morphology".

What does the interface to the manufacturing process look like?

The production file sent to the 3D printer is created directly from the geometry generation algorithm. The "digital chain" is short. With the necessary expertise, the finished component weighing 10 to 15 kilograms - the tolerance is less than 1 millimeter - is lifted from the printing bed. Just a few minutes of post-processing are all that is required and the component can be assembled.

What projects will the focus be on in the future?

We are currently focusing on exclusive cultural buildings such as museums, libraries and concert halls. In the future, all uses will be added, but they will benefit from the diffuse lighting provided by the translucent façade and energy input control. We are also pursuing strategies for interiors in which we optimize the surfaces for acoustics instead of shading: Exhibition buildings, integrated furniture walls, foyers, offices and conference rooms.

> "The step towards implementing morphological systems in BIM components is still a big one - as is the potential hidden in them."
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> Oliver Tessin

What is the current status of the refurbishment project in Munich?

After the change of the planning office, the architectural office RKW Architektur+ took over the planning. The opening date in the fourth quarter of 2020 remains the target.