Digital Technologies, Methods, and Tools in Support of the Architectural Development at Herzog & de Meuron

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INTRODUCTION

The architectural office of Herzog & de Meuron (HdM) started in 1978 and has grown, today, to a company of about 330 employees, with site offices in Madrid, Hamburg, London, and New York. Besides the two founding partners who participate in every project there are nine additional partners who take responsibility for individual projects. Project team members are hired from among highly qualified graduates of universities from all over the world. Furthermore, the office collaborates with artists and outside experts of various fields to support and enhance the available knowledge and skills. Today, buildings are being developed in Europe, North and South America, and Asia. The partners ensure that each project has a distinct and unique identity and is well adapted to its environment. This emphasis on the uniqueness of a project characterizes the design philosophy of HdM.

The growth of the office and the size and complexity of the projects has demanded continuous adaptation of the office structure. The amount of required data is increasing exponentially, while the design cycles are, generally, becoming shorter. There are individual design teams for each project, but their size is restricted. They have a top-down hierarchy and develop the project in a fairly traditional manner. Within the teams, individuality is fostered and supported. The design process is very fast. There are many design cycles and, therefore, many drawings, models, and prototypes to be made.

ANALOG AND DIGITAL TOOLS USED IN THE ARCHITECTURAL

At the beginning of a project, there is a strong conceptual architectural idea. The architectural process consists of developing this design concept and turning it into a workable architectural plan. The challenge is to find the right tools and media. HdM does not restrict itself to the realm of digital tools but, rather, uses all possible media: hand sketches in pencil, together with diagrams, drawings, and images, as well as physical and digital models. The media is used to translate the idea, not to create it. This raises the issue on how digital tools are being used in this context.

There has been a lot of talk about BIM (Building Information Modeling software). BIM is a digital approach that goes far beyond traditional CAD software by representing the project in the form of a database rather than pure geometry. BIM may be an excellent tool for firms that use standardized architecture. In our office, it is applied for specific projects that are ideally represented by a consistent database. However, it is not the right tool for all our projects: First, a lot of young architects are still not familiar with the underlying principles of BIM modeling and find it much more intuitive to work with pure vector geometry. Second, very often we do not have a unique, consistent model of the project, because different sub-teams are working on confined themes of the project, developing multiple parallel solutions. It is not easy to consolidate these solutions within a consistent model. Third, the uniqueness of each project makes it difficult to apply a BIM model. We have been working with BIM software and are continuing to use it, but not always with success.

A suite of generic CAD and graphic software tools is used in the office to develop the architectural design. These tools are used for image manipulation, diagrams, traditional architectural CAD drawings, 3D modeling, and renderings. Using standard tools allows for a very simple exchange between team members—an important issue at a time when project flow is often interrupted by economic conditions. The use of software should support the knowledge of the user, not replace it. If the user does not understand the basic principles of the geometry that he is using, then his ability to manage the component construction of the resulting project is compromised. For specific complex geometric tasks in-house generated software tools are being developed to support the architects.

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Physical models are a key component of the development process for the design team. In the office, a CAD drawing is not used as the sole document. Physical models are used in the first design stages to develop and verify the design intent. Models are made in all scales and sizes. Concept models as well as mock-ups are very important for the design cycles and are built throughout the whole design process. As such, a fully equipped analog workshop with excellent model makers exists in the office. To support and expand the analog workshop, a digital workshop has been built in the office that implements every existing and new technology—a strategy similar to that used in choosing our software. Our in-house machine park consists of three generic CNC-machines: a large, size 3-achses milling machine, a laser-cutting system, and a cutting plotter. The advantage of these three machines is that they can easily be incorporated into the analog model making, and the production processes are fast and simple enough to be managed by the design architects in the office.

Rapid prototyping models are outsourced; we have only a critical approach to produce them in house. Rapid prototyping is not very flexible, and the machines needed are not generic. They have specific input requirements and give specific output results. They are not as helpful to the design development as the three machines in the digital workshop. The result is often uninformative for anything besides visualization of geometry. Additionally, the models are difficult to incorporate into the traditional workshop. They are flat and monolithic and do not provide many insights into the component construction or subdivision of the project. We use this technology as a final output mechanism for presentation models. Another advantage of outsourcing these models is that this technology is still new, with new products regularly coming on the market. By outsourcing, we always have access to the latest available technology.

THE DIGITAL TECHNOLOGY GROUP

To be able to manage all the unique and different conceptual design approaches, a small digital technologies group has been created inside the office to provide support and create tools that allow projects to move forward. The group can be integrated into the design teams and is intended to enhance and support the creative abilities of the office as a whole. The group serves to facilitate architecture, not create it, and is able to deal with complex geometries in a flexible and adaptive manner.

The process of developing digital tools for design is one of developing programmed strategies that are focused to a specific idea defined by the design task. Typically it is about minimizing the driving input for the project while keeping the output parametric adaptable enough to all the different cases. Parametric tools must be created appropriately so as to ensure that the process can deliver the requirements of the design team. The main tasks consist in finding an abstraction of the design idea in order to map the idea into a digital data structure, and creating an efficient algorithm to process the data. There are cases where the numbers of exceptions within the design are so numerous that the whole project becomes a set of unique situations. At this point, the design team can either refocus the project to accept a more generic and flexible solution or move the design back to handwork or to the partner for clarification.

Speed is a critical issue in the design cycle. The technology group needs to work at the same speed as the design team. If one cannot move at the same speed as those working by hand, then the project will move away from the CAD group. Often it is the opposite: The only way to maintain speed is to involve the group so that design cycles can move fast enough.

DIGITAL CHAIN

The term "digital chain" represents the complete digital process from initial design to building completion. In the academic world, the digital chain has been realized in a number of small projects. At Herzog & de Meuron, the size and geometric complexity of projects make it very difficult or impossible to map the entire project process in a digital chain. Our strategy is to extract a specific design component and map this on a digital chain. However, this chain needs to be kept flexible. There are always moments when the architect breaks the chain by integrating a new manual input. An important task of our group is to integrate this input into the digital chain. When we realize a complete digital chain, the design data can be automatically transformed onto the production processes.

More than five hundred years ago, Leon Battista Alberti differentiated the intellectual act of designing from the act of construction in his book, De Re Aedificatoria; this separation is still in practice in architectural production today. In general, the architect hands his design to a construction company. From the architectural plan, the construction company develops a working drawing. The architect takes responsibility for the design; the construction company, for the construction. The complexity of some of today's architecture makes this process expensive and inefficient. The digital chain overcomes this separation. This is a very new reality in architecture and has yet to be evaluated from the viewpoint of liability and risks.

PROJECTS

Out of the variety of projects the digital technology group is involved in, the following projects demonstrate the span of its activities.

THE CITY OF FLAMENCO IN JEREZ DE LA FRONTERA, SPAIN (2003)

The City of Flamenco is a cultural complex that includes an auditorium, a museum, a school, and a documentation center. The Ciudad del Flamenco is situated in the center of Jerez de la Frontera, a Spanish city with a rich Moorish past.

The project consists of a partially perforated wall, following the historical lines of the city. A tower rises above this wall; its scale recalls the two towers of the Alcazar, and it also takes up an urban dialogue with the nearby cathedral. The materiality of the project is reduced to the traditional, homogeneous use of stone that characterizes the old town. The perforated wall itself, as well as the interior of the garden, forms a topography out of extruded, sunken and projecting bodies, generating a rich interplay between outside and inside spaces. The Ciudad del Flamenco is a radically contemporary and dynamic platform for performers and audiences.

The surfaces of the Ciudad del Flamenco consist of poured, perforated, and artificially processed concrete; they follow the lines, shapes, and patterns of Gypsy tradition and Arabic ornamentation. Both traditions are extremely contemporary; to be more precise, they are a centuries-old and ceaseless new source of inspiration for contemporary art and daily culture. We encounter them in punk and rock music, in tattoos, in symbols and emblems, in patterns, and in many other places. This kind of ornamentation informs the concrete material used at the Ciudad del Flamenco.

A collection of digitally generated tags were developed to create the ornament. From the tags, a perforated wall was designed, surrounding and supporting a tower and part of the enclosure of the building project. For the placement and the composition of the tags, a program was written. The ornament was to be made from concrete with openings resulting from the shape of the tags. The façade had to fulfill a variation of different functions, which defined the parameters of the programmed ornament.

Of primary importance was the consideration of static requirements. The weight of the building had to be carried by the ornament. For this reason, points were defined through which the loads of the slabs were conducted into the façade. Special tags were designed and precisely placed in the façade to fulfill this function. Another requirement was to leave several bigger openings to enable access for fire brigades in case of fire. Furthermore, the tags had to serve as sunshade, depending on the position of the walls. This again called for specific adaptations of the tags.

To develop the multifunctional ornament, a large number of processes were programmed that, step by step, led to the desired result. Some functions had to be met with a high degree of precision, others allowed for some scope of tolerance. To keep a high level of flexibility and allow, at the same time, high complexity in the design, different types of data were used to parameterize the façade. Parameters that needed a high geometric precision were retrieved from geometric input files; the other parameters were stored in pixel-based image files.

The ornament was developed in a continuous digital chain that could be interrupted at any time, and carried further by traditional methods. To enable the construction of the building, it was important to employ this approach. The final design exists as a conventional drawing and, likewise, as a model of digital data that can be used for the construction of the facade with CNC-controlled machines. Furthermore, the digital model allows for adaptations of the design and production of the ornament throughout the whole building process.

ELBPHILHARMONIE IN HAMBURG, GERMANY (2003)

The Elbphilharmonie is a cultural complex being built in the harbor of Hamburg. The design incorporates two distinct elements: a pre-existing brick warehouse and a new, crystalline tentlike structure that seems to float above the industrial base. A public plaza on top of the warehouse, high above the river Elbe, separates the two elements. It is a highly complex project, not only for its geometry, but also for the building program, which contains two concert halls, a hotel, and residential apartments.

Two elements of the project have been developed using a parametric scripting approach. For the concert hall, a tool to parameterize a sound diffusive surface pattern for the interior of the symphonic concert hall has been developed. Out of the acoustical requirements, the architectural intention, and the production process, a highly flexible design has been created for this specific task.

A second parametric approach has been undertaken for the design of the frit pattern of the glass façade. The glass façade, consisting, in part, of curved panels (some of them cut open), becomes a gigantic, iridescent crystal that catches the changing reflections of the sky, water, and harbor. In total, there are about 2,200 glass elements with a high variety of different sizes. To reduce solar gains, about 30 percent of the glass surface of each space behind the façade had to be printed.

BIRD'S NEST LAMP (2009)

The national stadium for the Olympic Games in Beijing, 2008, generally known as the "Bird's Nest," has attracted worldwide attention as a Chinese icon. A special lamp had been designed that was produced in China using traditional construction methods. This lamp will now be produced in Europe. It has been found desirable to parametrize the new model, as the exact parameters of its production are not known. The same geometrical principle as the one for the "Bird's Nest" will be used in the design of the lamp. Ribs should run over double-bent surfaces and meet in defined knots. Modeling this geometry directly is difficult to achieve. It is much easier to define the parameters in the 2D space and apply a transformation of them into the 3D space. This cannot be achieved with regular 3D modeling software, as a sphere cannot be unfolded in a plane. During this process, the points of the globe are defined in analogy to the degrees of latitude and longitude of the earth. Hereby, the distances can be stretched and the points can be exactly transferred from the circle on the globe. Therefore, the task is reduced by drawing the axels of the ribs on a circular surface. The knots of the existing lamp, thus, can simply be taken from the original model.