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The Modelling Process of the Tate Modern Brick Facade by Herzog & de Meuron

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Abstract

The present paper focuses on the project for the Tate Modern extension by Herzog & de Meuron, and in particular on the detailing of one of its most singular elements, the brick facade. Used to control the massive amount of data coming from the existing 336,000 bricks that form the outer skin of the building, digital scripting allowed the generation of a flexible 3D model that supported the visualisation and testing of the complex geometric issues that this material brought out in the construction of the facade. Even though this parametric tool played an important part in the decision-making process, it was just one of the factors in a design methodology marked by an enriching interplay between digital technologies and analogue methods, with modelling standing at the core of the whole process.

Keywords Modelling · Parametric design · Herzog & de Meuron · Tate Modern extension

Introduction

For Herzog & de Meuron (HdM), an architectural office founded by Jacques Herzog and Pierre de Meuron in 1978 in Basel, Switzerland, physical model making has always played a central part in the development of their projects. Made using different techniques at all possible scales and throughout the whole range of design stages, their models go from pure experiments with materials or abstract volumes that capture the design idea and translate it into the world of shapes to more detailed

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Fig. 1 The Herzog & de Meuron archive, Basel. © Jacques Herzog and Pierre de Meuron Kabinett (Foundation), photo: Iwan Baan, 2015

objects that describe the project with accuracy or are even developed as tests for material samples.

Since the perceptual dimension of architecture is at the core of the HdM practice, in the sense of how a building should both read, look and feel,[1] physical models are the means that allow them to go beyond a strickly visual experience and to set up the design process in an imperatively tactile approach. As though they were sculptures, models can be chiselled by hand and sensed from all angles so that every proportion or cut can be meticulously adapted down to the very last detail. HdM embraces this traditional method of defining architecture based on the dynamic manipulation of objects that are, in contrast to seductive digitally produced images, the '…testimony of an archaic understanding of body and reality', according to Jacques Herzog (quoted in Vischer 2004).

Established in 2015, at the lower levels of the Helsinki Dreispitz building, Basel (2007–2014), the HdM archive (Jacques Herzog und Pierre de Meuron Kabinett),[2] and in particular the two floors entirely dedicated to physical models and mock-ups produced by the office since 1978 (Fig. 1), clearly demonstrate this strong engagement with model-making as a fundamental tool supporting of the design process and whose scope they have especially broadened. Almost every study and project developed by the office has some physical traces here, so in this sense, this collection is a precious, almost archaeological, source of information about the work of HdM.

[1] For more about the thinking of HdM on the concept of perception in architecture, see (Herzog 1993) and (Meyer and Herzog 2013).

[2] See https://www.herzogdemeuron.com/index/projects/kabinett.html.

Grouped by project and following a chronological sequence, the many objects arranged on the shelves are often odd and enigmatic, making sense when seen as the crystallised stages of design thought processes. Together, they not only reveal the variety of HdM's oeuvre across the years but also suggest how the introduction of new techniques has changed the direction of their work. These intriguing artefacts, however, are a product of the mind, so they embody, in their singularity, a particular way of thinking about architecture. They allow us to go beyond the historical narrative of the work of HdM and are key to the understanding of their working methodology. They are unique in the sense that they are specific to HdM and are one of the distinguishing features of their practice, telling much about how they see the architecture but also how they approach the creative process.

Around 2005, with the growing size of commissions and the enlargement of the office from a local to a global-scale practice, HdM created an internal specialist department called the 'Digital Technology Group' (DTG), responsible for giving support to all the technological needs of the design process. From that moment, the capabilities of the digital medium, explored from the design to the production of architecture, were introduced into the office in a structural way, emphasising even more the role of modelling in the conception, description and construction of the architectonic objects.

In addition to the implementation of a digital workshop with CNC-machines that expanded the process of making physical models and mock-ups, digital tools placed virtual 3D modelling at the core of the HdM design process, and marked the beginning of their use of the computer no longer as a drawing machine but as a computational tool.[3] Therefore, as regards the drawing methods, the expansion into the third dimension was fully achieved by this time, when parametric tools were introduced and BIM started to be explored in some specific projects. As Kai Strehlke, head of the DTG until 2014, explained in 2009, '… a suite of generic CAD and graphic software tools is used in the office to develop the architectural design …' (Strehlke 2009: 26), allowing the production of traditional CAD drawings and 3D modelling. In addition, for specific complex geometric tasks, the DTG was able to create, in a flexible manner, customised parametric tools based on scripting that responded to the specific requirements of the design teams, facilitating the design of architecture and enhancing the creative abilities of the office as a whole.

This approach to design, strongly assisted by computational techniques, was particularly evident from 2005 to 2010 when the formal strategies for the projects clearly diverged from one another, and these were frequently characterised by architectonic components with a high level of geometric complexity. To handle the specificity of each design and, above all, to generate and control complex structures – which are not easily represented by traditional means such as 2D projections – digital modelling, and in particular that based on parametric methods, was revealed to be a powerful tool.

In order to examine this working methodology and acknowledge the role of both physical and digital modelling in the design process of HdM from planning to

[3] For more about the use of the computer as a computational tool, see (Peters 2013).

construction, the present paper focuses on the project for the Tate Modern extension (TM2), London, and in particular on the detailing of one of its most singular elements, the brick facade.

Begun in 2005 when HdM won the competition to enlarge the original Tate Modern (TM1), and concluded in May 2016, TM2 is a significant example where the use of scripting was fundamental for controlling the massive amount of data coming from the 336,000 bricks in the outer shell of the volume. By allowing the generation of a 3D model of the entire brick facade, scripting assisted in the visualisation of the brickwork arrangement and testing of the complex geometric issues that the brick as cladding material brought out in the construction of the facade. However, even though this parametric tool played a crucial role, it was part of a set of means that together allowed the design idea to be grasped, and that contributed to making it buildable. As usual in the practice of HdM,[4] the design methodology for TM2 was marked by an enriching interplay between digital technologies and analogue methods. Standing at the core of the whole process, modelling was explored in its most varied types, from traditional physical models and small virtual models made by hand to a large 1:1 scale mock-up of an entire corner of the building and the parametric point cloud containing the complete information of each brick.

The Tate Modern Extension

Four years after the opening of TM1 in 2000, HdM started working on the design for the second phase. For the architects, this was an opportunity to return to a very esteemed project that meant so much in their career. The conversion of Gilbert Scott's building into the first public gallery for modern art in London was the project that brought HdM, at the beginning of 2000, into the realm of the most acclaimed architects globally. TM1 was an important stepping stone in the evolution of the office that marked their transition from a local to international-scale practice.

The studies for the extension of TM1 began with the realisation of a scheme that Nicholas Serota, former director of Tate and client for both TM1 and TM2, decided to pursue, concerned that they might lose the rights to construction following the continuous rise of new buildings around the museum. Between 2003 and 2004, HdM worked on the masterplan that established, based on zoning laws for light and views of St. Paul's Cathedral, the volumetric constraints of the new building, outlining the general envelope into which the entire extension would absolutely have to fit. This turned out to be the first given of the project that determined from the very beginning the volumetric features that would be common to all the design proposals. A pyramidal tower should rise adjacent to the Switch House's southwest corner, becoming visible from the north bank of the Thames as a signal of the new intervention (Fig. 2).

In the project for TM2, the architects dealt with two major questions that ended up becoming the two most specific architectural features of the building. The first

[4] Jacques Herzog speaks about their methodology in an interview, see (Curtis 2002).

Fig. 2 The Tate Modern seen from the north bank of the Thames. Photo by the author

was about the spatial organisation and the internal connections between all the parts. It was about how to fit everything into a restricted, given, tent-like shape, and—even more complex than this—how to distribute the whole program in a vertical arrangement over ten floors. The second issue had to do with the outer appearance of the building. This led them through an intricate design process, where different proposals in the search for the appropriate solution for the shape and the outer material of the building were considered and explored almost as complete projects.

In fact, when looking at the design process of TM2, the 'schematic design' stage, which took about 3 years, emerges as one of the most significant moments in the development of the project. Even though the basic principles of the intervention had been set up in the studies and had always been clear, their translation into an architectural form was far from being straightforward and led to distinct configurations. In the course of this prolonged phase, three projects corresponding to three different design approaches were fully developed until the idea of a pyramidal tower covered by a perforated brick veil emerged as the most reasonable proposal to be adopted. The decision, as Pierre de Meuron explained, to '… use the same cladding for the old building and the new extension, namely the bricks, … [to unify] the entire complex so it can stand out to its neighbours' (Dercon 2016: 105)—which now seems to be obvious and fitting for the site—was not the first proposal by the architects.

The significant number of study models and the series of variations tried out on them clearly illustrate this intensive, experimental and non-linear creative process developed in search of the ideal architectonic solution for TM2 (Fig. 3). Three specific compositional procedures—morphing, stacking and twisting—stand at the core of the three different versions of the project. Understood as devices that guided the many decisions to be taken, these geometric operations and this particular way

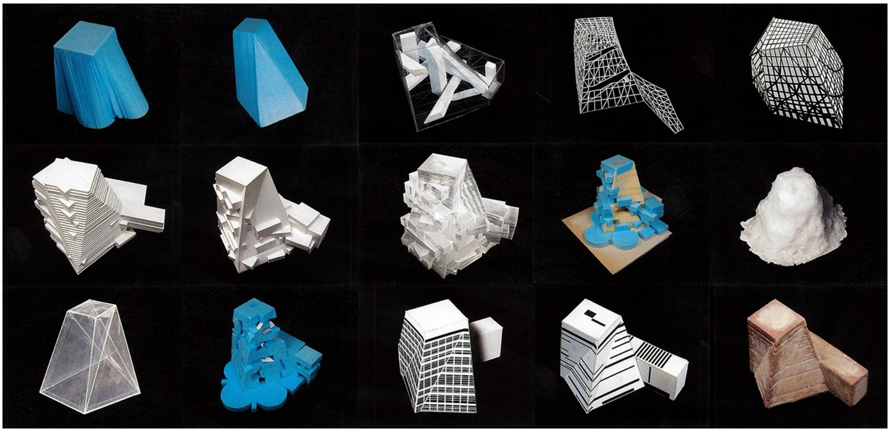

Fig. 3 Study models developed during the 'schematic design' stage for the Tate Modern extension (TM2). Image © Herzog & de Meuron

of tackling the definition of the form based on clear volumetric approaches are representative of the concept-based methodology of HdM.

At the beginning of this process, both the client and the architects believed that the new building should have its own integrity and be somehow separate from the former power station. For a long time there was a reluctance to consider using brick. Therefore, before crystallising into a pyramidal brick form, TM2 was in its first iteration a glazed tower. With a steel frame structure on the facade, the overall shape was generated by the extrusion of a figure that morphed as the volume rose, becoming smaller and acquiring a different configuration when it reached the rooftop. In its second version, the project became even more striking. Clad with laminated textured glass panels, the new TM2 took the form of a massive pile of distinctly oriented boxes stacked on each other. In a way, the same sculptural approach based on the additive process of layering that the architects were concurrently exploring in iconic projects in China, Basel and New York[5] was also tried out here in London.

However, even though the trustees were satisfied with the glass stacked boxes project, the architects began to feel uncomfortable with it and were no longer convinced that this would be the right direction for the project. According to Harry Gugger,[6] the partner in charge of the project until 2009, they realised that the glass conferred a generic character on the building and that overdoing the pyramidal shape with the boxes resulted in a too glamorous approach, totally opposite to what

[5] We are talking specifically about the projects of HdM for the Beijing Film Academy Qingdao, Qingdao (2005), Actelion Business Center, Basel (2005–2010), VitraHaus, Weil-am-Rhein (2006–2009) and 56 Leonard Street, New York (2006–2017). For more information about these projects, see (Mack 2008) and www.herzogdemeuron.com.

[6] From a conversation between the author and Harry Gugger on 20 February 2020 in Basel.

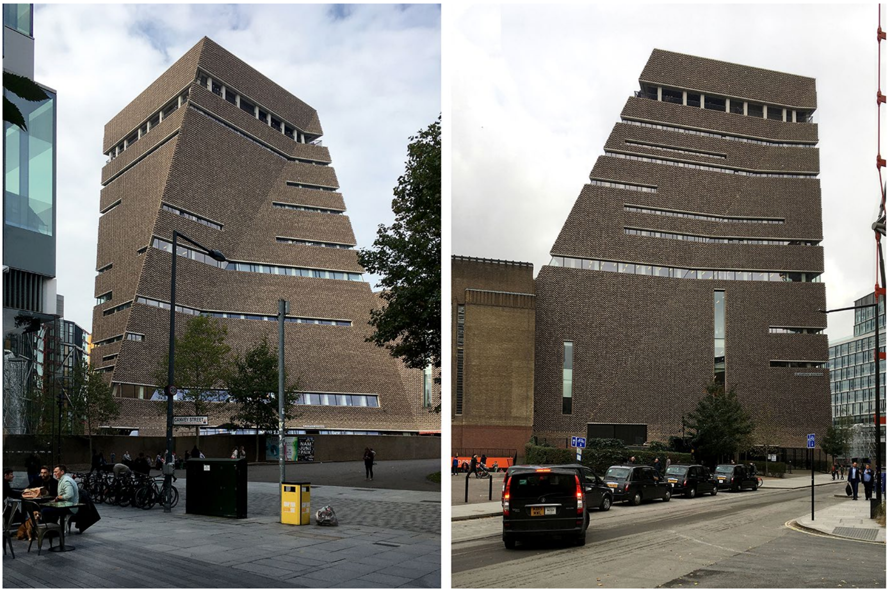

Fig. 4 The TM2 brick pyramid, east and west facades. Photos by the author

Tate Modern was meant to be. From this moment, it seems as if the mindset of the architects changed, and the last revision was undertaken, leading to the final version.

A Brick Pyramid

Two main operations led this revision process, both having an impact on the new building's external appearance and on the dialogue that from this moment was established with Gilbert Scott's original power station building. Together with the decision to simplify the outer shape, brick was chosen as the cladding material for TM2.

The architects, as Jacques Herzog described, '… dissolved the stacked sugar cubes' (Dercon 2016: 106) and decided to return to the primary form outlined in the previous design. The general shape of the building became a very clear and precise truncated pyramid, made of vertical and inclined faces that intersect each other along oblique lines, and whose twisting movement is trying to absorb all the combined geometries given on the site and in the existing building (Fig. 4).

The idea was that the two parts, old and new, should come together in a coherent whole, so the architects decided to cover the extension volume with the same brick as the former power station. It was no longer about making the building stand out by its conspicuous presence, but on the contrary, it was about working with the given features of the site, enhancing the qualities of the original complex and seeking to innovate while ensuring a crucial continuity.

By taking the same constructive principle of the old fabric, a steel frame clad with a non-load-bearing wall, the facade of the pyramid became a mighty concrete skeleton growing from the underground world of the oil tanks, over which is literally hung a perforated brick skin. A specially designed brick was developed to complement the rough variegated masonry walls of the former station, and the brickwork was explored in an unexpected new system that emphasises the distinctive ability of HdM in the use of 'vernacular invention'.[7]

The new brick, the primary element of the intricate outer veil, results from the standard size brick whose dimensions were adjusted according to the specific architectonic and construction demands of the extension building. With the same stretcher dimension as the traditional brick, the new clay block was doubled in depth, acquiring a square shape measuring 215 mm. per side and 69 mm. high. Assembled afterwards in pairs with a nominal 7 mm. joint of a polymerised mortar, pairs of bricks were put together in the factory, forming a single block measuring $215 \times 215 \times 145$ mm (Fig. 5).

The brickwork of TM2 follows the same Flemish bond as TM1, with the blocks being offset horizontally by a nominal header dimension of 122.5 mm. In this bond pattern, the headers were removed to create the desired perforation.

The brick wall then responds to the shape of the twisting pyramid made of vertical and inclined planes. On the sloping faces, the blocks are offset at each course, adapting their arrangement to the specific angle of the inclined surface. As a response to the brick rows that step over the inclined facades, on the vertical walls the courses are also offset 44 mm. in and out of the wall plane, ensuring the continuity of the brickwork texture in all eight surfaces of the building. Placed on top of each other for just some centimetres, the blocks, with four holes inside on the top and the bottom, are connected by a precise system that uses elastomeric joints and stainless steel pins (Fig. 6).

The scaling-up of the brick element and the adjustments made to the bond resulted from a careful calibration that took into consideration not only the structural and geometric constraints coming from the shape of the pyramid, but also the effect of transparency that HdM wanted to achieve in the outer skin of the building. While on the one hand the increase in brick depth was mainly concerned with the stability of the external walls that raise 65 m. above the ground floor level, with the blocks laid on each other and overlapping just on a small part of the bed surface, on the other hand the definition of the course height was directly linked to the amount of daylight that filters through the holes of the omitted headers.

Despite being just one of several layers of the facade, the brick veil, due to its modular nature coming from the blocks' standard size, impacted many aspects of the building. Marking the elevations with a sequence of horizontal and vertical lines offset at a regular distance, both the brick course and the horizontal header interspace became the units of measurement that ruled the composition of the facade as well as determined

[7] 'Vernacular invention' is a term used by the French art-historian Jean-François Chevrier to describe the work of HdM from the point of view of the relationship they establish in their architecture with the context; see (Chevrier 2016: 19–23).

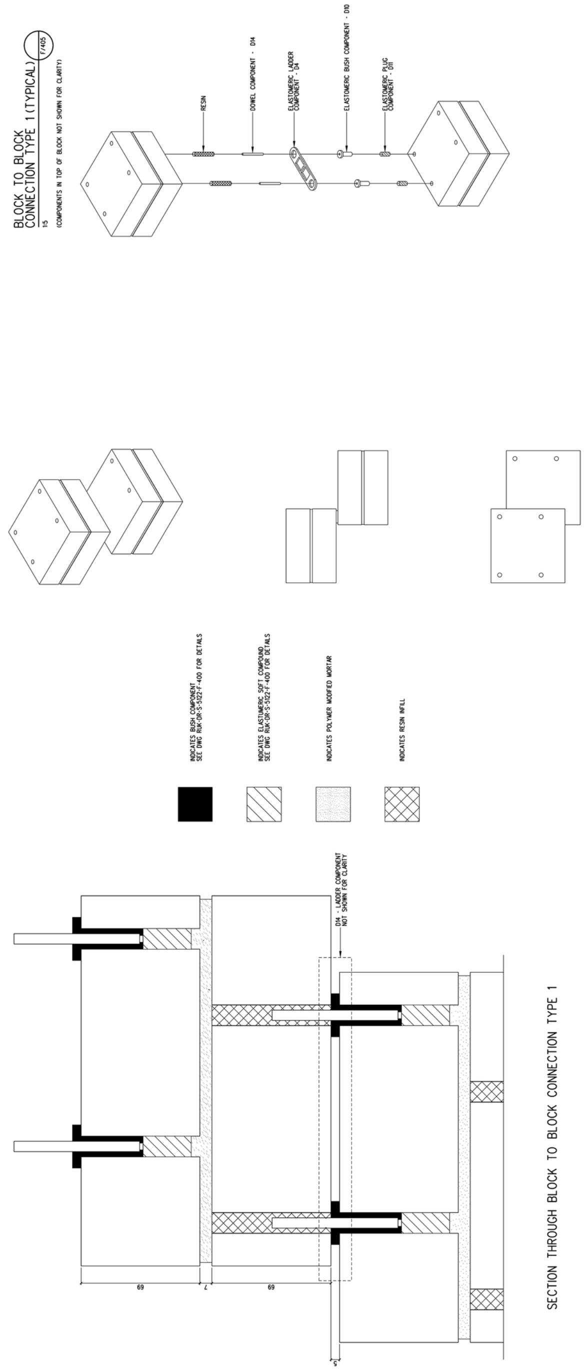

Fig. 5 Typical block to block connection. Drawing © Herzog & de Meuron

Fig. 6 The standard block and the regular perforated brickwork. Photos of the mock-up constructed in 2010 in London. Photos © Herzog & de Meuron

the floor heights and the position of the precast concrete columns and beams. However, from the intersection between this regular grid and the pyramidal twisting shape, several exceptions to the arrangement of the bricks emerged. Three particular situations in the building envelope with a particular geometric and constructive complexity had to be solved in the design of the facade. The cut out of the brick veil for the openings, the anticlimbing system at the bottom of the volume and the resolution of how the inclined and vertical faces meet at the corners and creases led to the detailing of special conditions.

As exceptions to the regular bond, these situations required special pieces, different from the standard block, which in itself had to be considered with particular regard since this is not a mortared wall where the bricks could be easily cut on-site or slightly adjusted when being laid. Due to the particular interlocking system of the blocks, their internal structure with the holes inside had to be taken into account alongside the outer shape of the pieces, which not only added technical complexity to the solution but also multiplied the array of brick types needed.

In addition to these geometric issues, the colouring of the bricks was another topic that the architects also intended to explore. They wanted to achieve a smooth colour gradient, from darker colours at the bottom of the building and lighter at the top, which introduced additional variations within the brick types, increasing the complexity of the information to be managed, not only from a design point view but also production-wise.

Therefore, the rationalisation of these design issues emerged as the great effort to be undertaken within the detailing phase. Precise rules had to be found that, besides translating the architectonic idea, would aim to optimise both construction and production systems. By establishing clear and simple logic for the arrangement of the blocks and reducing, at the same time, the number of brick types, the construction process became more controlled, and the costs, in general, decreased.

The Modelling Process

The method undertaken by the design team to study, test and find the right solution for the special brickwork conditions, with the corners being the most challenging, was primarily assisted by physical and digital modelling.

Fig. 7 The 1:1 scale foam models used to test the brickwork system. Photos © Herzog & de Meuron

As Wim Walschap, the associate in charge of the facade, explained, the architects started by making physical models at 1:1 scale:

> We built the blocks in foam. We had two or three of these regular surfaces with the bricks meeting at the corner or crease, and we explored in the model the options to resolve these edges and how we could introduce a system. After this, the most promising solutions were further tested in Rhino, in very basic 3D modelling.[8]

The construction of foam models (Fig. 7) with the single blocks at 1:1 scale and the reproduction of the details in the digital environment were fundamental to simulating three-dimensionally the particular situations of the brickwork and having a clear perception of how the pieces were combined between them. By dealing directly with the shape of the objects, physical and digital models were revealed to be ideal for manipulating the bricks and easily testing different options. It provided a full insight into the final result and immediately allowed the architects to recognise the possible geometric incompatibilities. There was a back-and-forth process until the architects found satisfying pragmatic rules that would ensure an easy production and construction process.

However, this modelling work focused on specific sections of the brickwork. Even though it allowed the team to develop the single details and to test the rules themselves on their absolute conditions, it didn't provide the control of the whole facade. It was impossible to build a complete physical model of the volume with all the bricks, in the same way that it would be difficult, due to the amount of information, to have and manipulate a full digital model of the brick veil. And even if these had been made, they would have become rigid models that would have barely supported the fundamental trial and error method of the design process. So this methodology, which was ideal for analysing and deciding on the individual

[8] From a conversation between the author and Wim Walschap on 16 July 2020 (Zoom meeting).

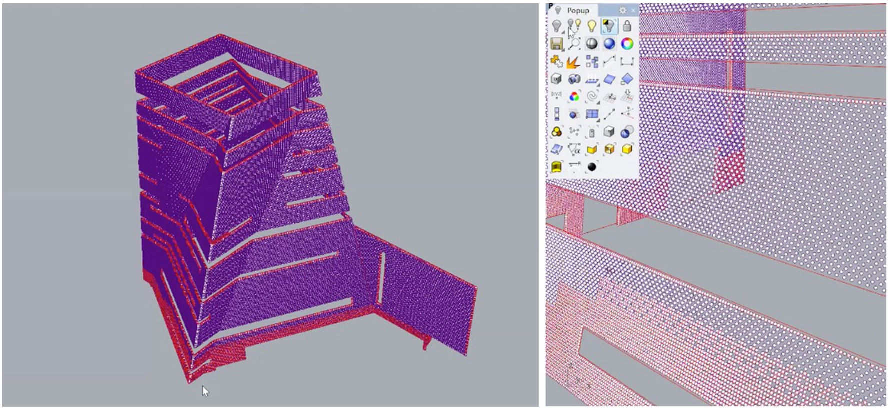

Fig. 8 The point cloud for the parametric model. Images © Herzog & de Meuron

parts, did not show how the rules would work when applied in the whole facade, and did not give the architects the full precision that could only be achieved by the integration of the details into the overall set-out of the brickwork.

Therefore, when the brickwork issues began to be approached, the design team collaborated with the in-house DTG, and their programming methods supported the design process. Scripting assisted the investigation of solutions, helping to simplify certain tasks and give faster results, but most importantly, helping to overcome the gaps of the conventional analogue and digital tools, allowing the architects to push the design forward.

The architects and the DTG collaborated intensely, emerging from this interactive relationship with a strategic methodology based on a descriptive versus parametric approach.

Standing on the descriptive side, the architects' team addressed the design development with tools that relied on the construction and representation of 3D forms. Either by graphical, physical or digital means, they focused directly on the objects through the construction of models, complemented by hand sketches, orthogonal projections and very simple renderings. While the design team dealt with the geometric description of shapes, the DTG worked on the explicit rules for the geometry underlying the resulting forms. Addressing the architectonic idea from a parametric perspective, they attended to the compositional relationships and the design components with their associated variable input values. Taking advantage of the computer's proficiency at executing a complex set of instructions, and by the use of scripting, the DTG automated the brickwork design procedures, enabling the generation of a flexible 3D model that allowed to tackle the existing shortcomings.

The scripting was intended to bring together the information about all the existing bricks in the facade, as well as take into consideration the many design issues that were being investigated. Nevertheless, despite this huge quantity of information, the resulting parametric tool needed to be easy to manipulate and be adaptable enough to respond to the design team's continuous demands. For these reasons, Kai Strehlke, who was guiding the digital process, realised that the scripting should

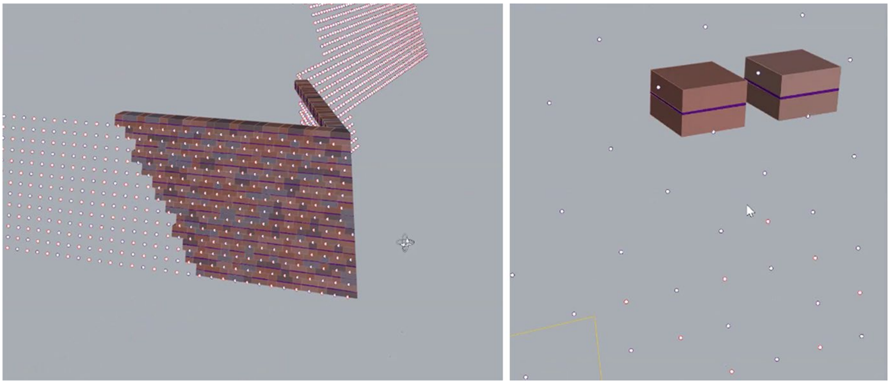

Fig. 9 The bricks generated as polysurfaces. Images © Herzog & de Meuron

not depend on the geometric representation of the blocks. He decided to set out the whole data structure on a point cloud, a strategy that he said they hadn't used before.[9] Each brick on the facade would be represented by a single point whose name would collect all the information about that specific piece (Fig. 8).

The whole scripting process worked on a very simple input geometry. It consisted of the eight vertical and inclined external surfaces plus the polylines defining the frame around the windows and the louvres so that the information exchange between the architects and the DTG was easy and straightforward.

Besides the input geometry, the special conditions for the brickwork were also scripted. As the team worked on the details, the DTG wrote small scripts for the geometric rules that were being tested for the corners and creases, the anticlimbing system and also the sills, reveals and lintels of the windows. Therefore, once the point cloud was generated, each of the points, placed at every stretcher and header position, was informed by all the data concerning the geometric features of the corresponding block. Because all this information was condensed into a set of codes inside the name of the points, when a specific script was re-written or added to the main structure, the parameters associated to this function would automatically be renamed and, consequently, the properties of the bricks would change. This allowed the team to shorten as well as simplify the update process for the parametric tool.

The scripting was also developed to generate the bricks as polysurfaces in the virtual model (Fig. 9). Therefore, by selecting the desired number of points, it was possible to visualise them three-dimensionally without having to render the whole model. This became one of the most useful functions for the design process. It gave the team the ability to easily visualise the experiments that were being developed by hand with great accuracy and applied to the whole facade. If the architects changed any details, the geometric relationships and the associated input values had only to be updated in the script so that the digital model would show the new versions of the design.

[9] From a conversation between the author and Kai Strehlke on 6 November 2019 in Zurich.

While being generated three-dimensionally, the bricks could also have a specific colour applied to their surfaces. As the colour of the facade became a relevant topic in the design, a script was also developed to assist the colour testing process, which was running on a very simple input diagram existing in the model. By manipulating this diagram, the architects were able to easily explore all kinds of colouring variations. This function enabled them to test in a very intuitive way the colours of the thousands of bricks, but most importantly, it made this design idea viable, which, by traditional means, could hardly have been accomplished.

In addition to some other functions that enhanced the use of the virtual model to inform the design process, the scripting also provided commands that assisted the graphic description of this complex brick facade by allowing the generation of 2D drawings, as well as the creation of lists of all the blocks used in the building. This automatic calculation of the number, and the several geometric configurations and colours, of the bricks, which would have been difficult to obtain without the computer's information processing capability, was instrumental not only from a design point of view but also in terms of production. Having the exact control of the bricks quantities per type during the design process allowed the architects to optimise the solutions, and at the same time it made possible later, during the construction phase, to make lists and schedules for the brick manufacturer of exactly what to produce.

Conclusion

The first aspect that the TM2 brick facade project reveals is the great potential that modelling, as a design tool, has for controlling architectonic issues of a high level of geometric complexity.

In the specific case of TM2, scripting was crucial to provide a digital model of the entire brick facade in which all the design information, tested and validated by complementary methods, was also assembled. In the end, this parametric model turned out to be a versatile tool, fully integrated into the working methodology that supported the design process in all of the aspects where more conventional means are revealed to have some limitations. However, it was only possible to achieve this through the close dialogue established between the DTG, guiding the parametric approach, and the architects' team, which was from the decision-making side and was conducting the process by descriptive means. The two design approaches merged into a well-balanced exchange process, mutually reinforced, and led to the establishment of a complementary tool set that together allowed HdM to grasp the architectonic idea and make it buildable.

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