Big Scale Landscape Project from Design to Fabrication: A Report on Digital Methods

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Abstract: Most landscape projects share a similar history: they start with an idea, continue with seemingly endless planning iterations of each profound planning phase and end in a more or less successful fabrication stage. As the size, budget, and timeframe of the project are often fluctuating during the process, digital methods can help us to cope with them. This paper reports about digital methods used to realize the project "Summer Island" at the Bundesgartenschau (BUGA) 2019 in Heilbronn, a big scale landscape project as a part of the Federal Horticultural Show in Germany.

Keywords: Digital design methods, digital fabrication, parametric model, digital landscape

1 Introduction

The Bundesgartenschau BUGA area in Heilbronn with its inner part called "Summer Island", is situated between the canalized Neckar river and one of the river's branches and was held from 17th April until 6th October 2019. This area used to house wet docks as well as industrial and railway facilities. The Summer Island itself lies between two former wet docks, which today are named Stadtsee and Karlsee. The BUGA laid down the infrastructural ground (ERHARDT 2013) for a huge housing development situated very central in Heilbronn. The Berlin landscape architects Sinai did the design for the master plan. LOMA architecture.landscape.urbanism was commissioned in 2016 to design the temporary development of the Summer Island.

At the beginning of the planning phase, in 2016, the summer island was covered with large soil piles. Excavators, large trucks and tipping lorries had piled up huge depots of the river Neckar's clayey alluvial soil here – a material more suited to creating a lunar landscape than a base for a horticultural show. The construction site (Fig. 1) had nothing in common with the predefined term of "Summer Island" but it was more like a "zero-place". The planning task was to develop a vision for this huge area that should also deal with all the stored material without removing it from the site and preparing it for building quickly and within a limited budget.

The paper will report about digital tools in the different phases of the project. These phases were not lined up one behind the other but were overlapping during the whole process. This means that during the development of the schematic design, there were already tests made on simple parameterized models to calculate the material masses. Moreover, parallel to the design development, experiments were made to extract construction drawings from the 3D-model.

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Fig. 1: Excavations at the Summer Island

2 Report on Digital Methods

2.1 Design

The Summer Island landscape design is based on creating the soil's natural wave formation, which forms ripples analog to a glacier-shaped, gently undulating moraine landscape. The visitors should be able to walk on and between the ripples. Early drawings of natural science from the 17th century were studied, in which cartographers had tried to trace the Upper Bavarian moraine landscape. Application of this analog technique to synthesize a new and unique landscape for the Summer Island failed. During the schematic design, the need to use digital methods to create the landscape was recognized early. The expertise in digital methods at LOMA was there through a previously realized project, the Ripple Park, that was accomplished with a fluid Add-on of Maya Software in 2008, a time when processual and parametric digital tools in modeling software were not widely known yet.

One of the project's important parameters was 16,000 m^3 of soil stored on the site that had to be built into the design. This earth amount was not a fixed number as there were ongoing excavations, and Summer Island was used as a storage area. So any design had to keep flexible with the volume. Another long undefined parameter was the number, location, and size of pavilions which were planned very late and significantly impacted the distribution of material on the site. The Summer Island's surrounding streets and infrastructure were already realized so that only several cable trenches had to be planned and incorporated into the design.

The new landscape was parametrically realized with the 3D modeling software Rhino 3D add-on Grasshopper. Nurbs-curves placed on the site formed the main input for the parametric model that created each formation element. The height of the element was parametrically coupled to the length so the inclinations were in between a predefined range. Furthermore, the endings of the elements were defined with some built-in irregularity. The goal was to have a simplified geometrical input (the nurbs-curves), as this would speed up any changing of the wave formations. As the Summer Island was supposed to be a complex wave system that contextualizes spacial or dramaturgical demands, three-wave patterns differed from each other with diverse individual properties (Fig. 2).

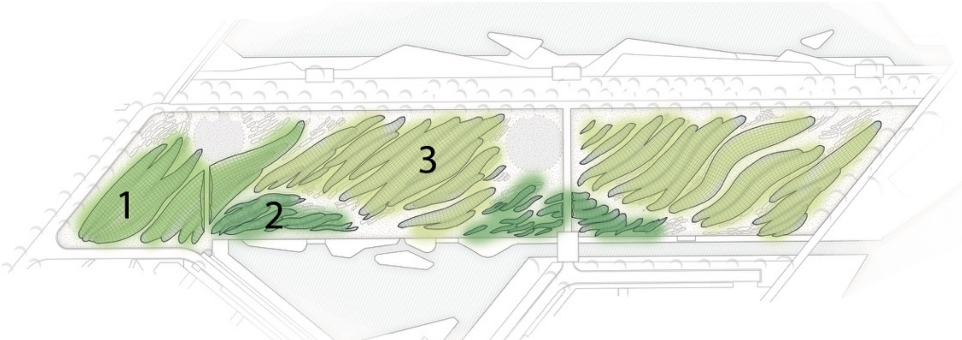

Fig. 2: Summer Island wave types. Type1: higher wave in ratio to the length, simple curved ridge; Type 2: small waves with alternating slopes; Type 3: lower wave in ration to the length, undulating ridge

Except for type 3, the wave's height would be defined by the underlying curve's length. All waves had, depending on the type, fixed slope angles that were defined in a specific range so people could still climb them, the robotic mover would be able to reach all points, and the grass would not slip. Even though the elements are formally rising out of the ground, they had to be technically modelled as attached objects so that they could be modified easier during the process. South-west of the Summer Island, an adjacent area called Rose Garden was also located, and its individual ripple pattern was formally not connected with the huge wave formation of the main area of Summer Island.

During the design process, the form of the waves changed, so the overall picture was determined by the density – depending on the earth volume -, the wave's thickness – thinner at an earlier stage – and the wave's shape – getting more expressive with much sharper or wider heads. These changes are the result of continuously adapted parameters (Fig. 3), like the volume of stored earth, changing client requests – they demanded a "tribune"-like wave toward an open stage, as well as infrastructural needs – some shafts on the site had to be accessible

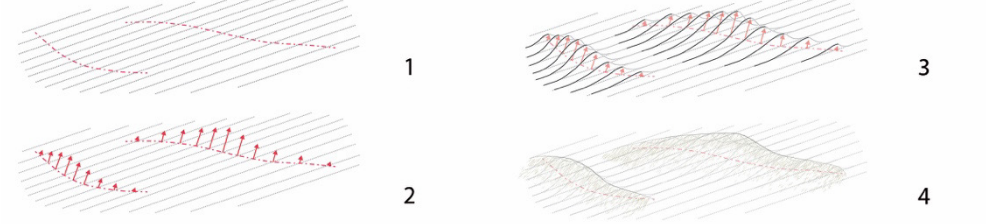

Fig. 3: Main parameters: 1 – Curve positioning; 2 – Height distribution from 1 – 9 meters; 3 – Slope definition; 4 – Topography

for vehicles. One of the last "settings" was the precise positioning of the two pavilions (SONNTAG 2019, BODEA 2020) and the definition of their installation space.

Starting from the scheme development towards production drawings, only one 3D model was used. This model was repeatedly refined through the process and broke only once. When a parametric model brakes, it means that all components' internal setup configuration cannot fulfill proceeding development and needs to be reconfigured from the ground up (DAVIS 2013). This happened during the setup of new wave types, and it was recognized that additional types have to be organized universally and extremely flexible. As Grasshopper is a graphical programming tool, there is no possibility to set objects and classes like in normal programming languages, but a similar approach was chosen.

2.2 Planning

One of the uncertainties of this project during the planning process was how the landscape would be actually built. The bidding process for the earth surface modulation has not determined the building technology. Two scenarios were possible: building by the construction drawings or by the 3D construction model. This means that preparations were made for both, but the main work was outlining a strategy for extracting construction plans out of the model. Also, the client was not clear what to collect for the documentation as that would mean he needed to handle hundreds of plans.

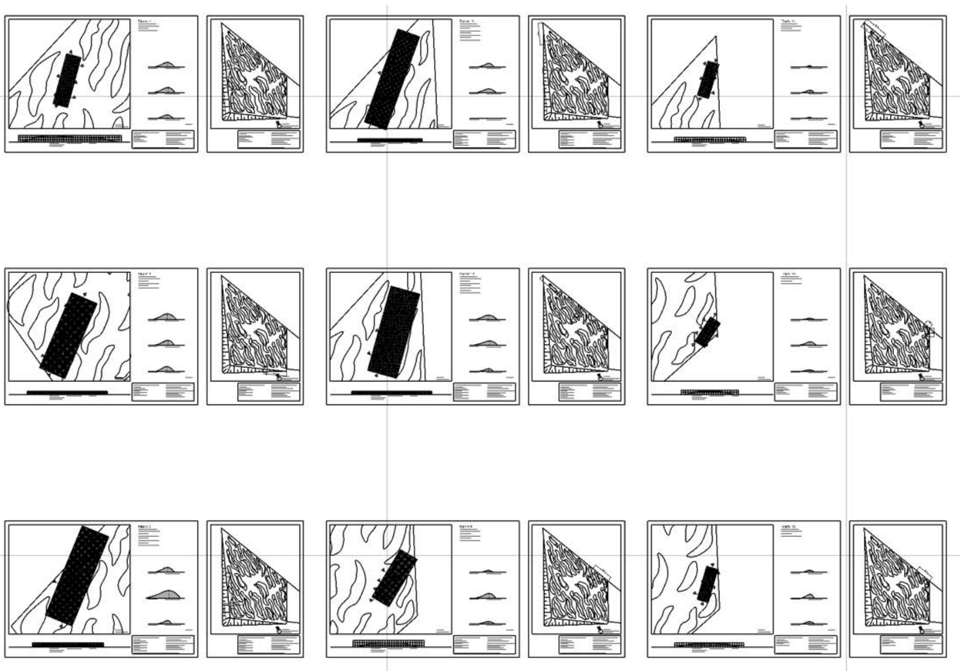

Fig. 4: Excerpt from a set of automatically delivered construction drawings for a part of the Summer Island called Rose Garden. Every ripple had its own detailed drawing and a DIN A4 page with its dimensioned position.

For the scenario of producing construction drawings, the solution came from the same parametric system as it allowed to automatize the setup of detailed drawings and sections together with automatic numeration, scaling, dimensioning, and labelling. The extracted floor plans and sections were parametrically scaled down (from 1:1 to the desired scale) and were populated with dimensions measuring the important points. This system was tested and found effective and reliable, although a final human control was necessary.

Shortly after finishing the design development, a more precise measurement of the terrain was incorporated into the model. The model was moved from its previous zero-near position to the actual coordinates, in this case, according to the Gauß-Krüger coordinate system. As the distance to the zero point was about 3 10^{6} in x, y, and z, it was recognized that the model is not practicable as the program had to calculate all drawing information with a huge increase of the number sizes. The rendering process was flawed and the whole model unstable. As all outgoing site plans had to fit and be referenced, a solution was found to leave the original model at the near-zero position and insert it into a block. This block has been referenced to another block with an exact position in space.

Getting the right coordinates was also important for establishing basic slopes for the surfaces between the waves and planning the drainage system. Drainage pipes were positioned in areas where rainwater could not drain away. Those channels were then also built into the model to detect eventual intersections with other infrastructural elements.

2.3 Fabrication

The prepared dual setup of the drawing output, classical drawing plans, and a 3D-model turned out to be a good decision as two companies with complete opposite building strategies won the tenders: one that wanted to handle terrain modelling with drawn construction plans at the area of the Rose Garden and the other that got the main area of Summer Island and wanted to utilize the 3D construction model. Both companies could be served immediately, and the deadline pressure forced a quick delivery of data.

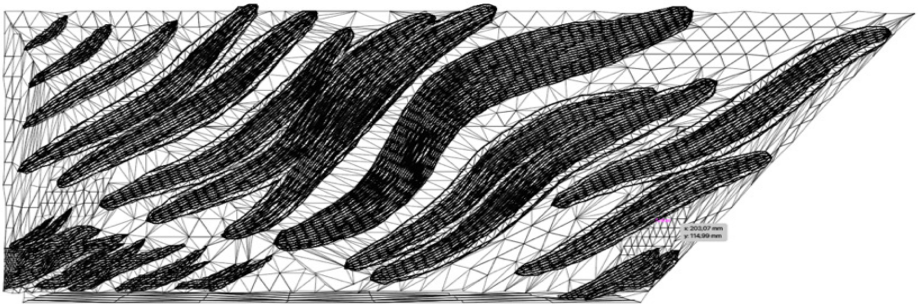

Fig. 5: Exported triangulated mesh of the northern part of Summer Island

The workflow of exporting the 3D model for fabrication contained several preparation steps. As the Rhino3D model is a Nurbs-model with all elements as separated entities, all objects had to be merged cleanly. This was only partly possible in the parametric model and, for the sake of precision, was done manually and inserted back to the parametric model. Here this model was transformed into a mesh model (Fig. 5) with adapted mesh resolution. A resolution gets higher where the model gets more complex. The triangulated model needed to be “waterproof”, without any open edges or missing faces.

The excavators that modulated the terrain were equipped with GPS-sensors and an internal referencing system (Fig. 6). During the machining, the conductor's aid was established with visual and sound feedback and delivered a precision of 1 cm. After the main terrain modulation, minor onsite manual corrections were made to improve the waved landscape's effectiveness.

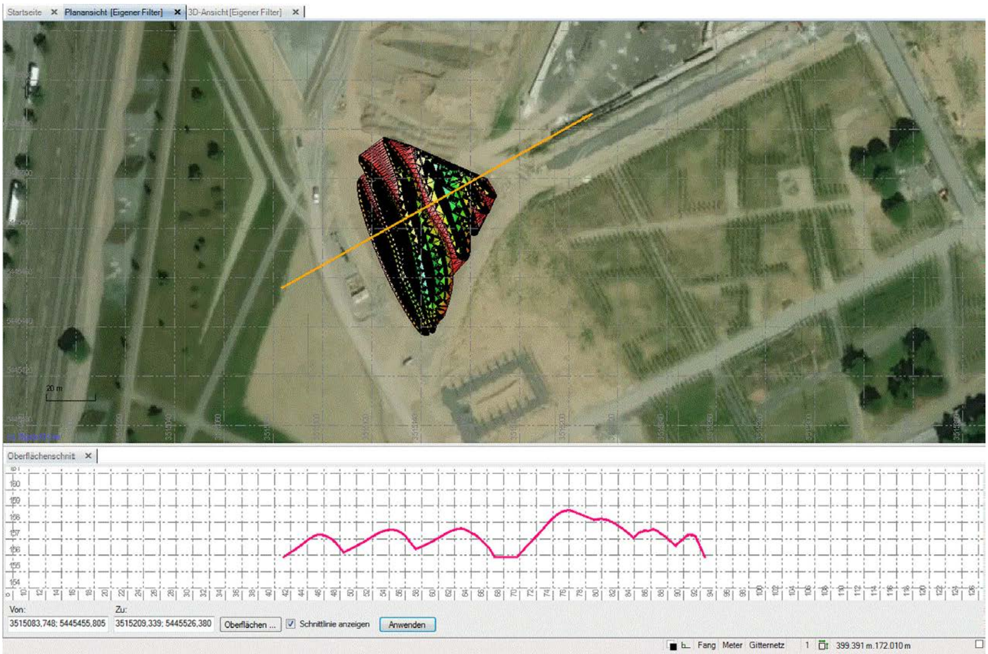

Fig. 6: Imported model in the software system of the construction company Wolf und Müller before transferring the data to the excavators

3 Conclusion

Temporary landscape projects like BUGA exhibitions (Fig. 7 and 8) that are suited very well for experiments cannot be directly compared with long-life landscape projects. These horticultural shows are not only sandboxes for form creation but also for upcoming planning and fabrication methods. Like most landscape projects this project also started with an idea, continued with planning iterations and ended in a successful fabrication stage. The difference to any usual process was the extremely limited planning and construction timeframe. The implemented parametric model fitted well with all the constraints and limited time. The formal simplicity paired with an uneven and complex output also helped the client pursue all the stakeholders involved.

Fig. 7: Areal view of the Summer Island at the BUGA 2019 in Heilbronn

Fig. 8: Visitors view of the Summer Island

Having all data and numbers ready at all times helped in avoiding unpleasant surprises. This was one of the reasons the project had no cost increase. During such a development, planners are urged to build models that can quickly react to different situations. To be one step ahead is a valuable planning strategy. Building up and developing a parametric 3D model and maintaining it over the whole process of planning and during the construction time can be crucial for the project's success. As the planner is also a programmer, he or she has to organize the data and communication with the project leader, similar to how software engineers organize their software projects. The danger of the project running into a bottleneck at the parametric model is very serious. For this, at least two persons must share the same knowledge, the structure, and the detailed workflow of all elements in the 3D model. One essential part is the right documentation of all programmed parts and, if possible, a written and drawn explanation about the output. A comprehensible file storage system of directly related files: 3D model, parametric model, plan output, has to be made.

4 Outlook

The advances in parametric modelling helped this project through all steps from design to fabrication. It utilized the whole spectrum of available tools in the software package Rhino 3D and made the project highly adaptable through the planning process. Still, the next big landscape projects will probably be done with tools that are nearer to the natural growth of forms and with the help of digital generative methods, with the consequence of reduced formal control of the model. Furthermore, the result can be a cross of landscape architecture and landscape planning with social, climatic and ecological topics coped with a distinctive, surprising and unique appearance.

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