venTUM

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Preface

venTUM - a merge of the latin word for wind and the name of the Technical University in Munich. In line with the name, we tried to follow a design approach that combines the topic of sailing and water with the technical challenges of the projects functions. This led to the significant roof shape which forms a wave while giving room to all the necessary activities happening in both the boat house and the workshop. The TUM trademark - exposed concrete - is used where structurally necessary making venTUM easy to identify as a university building. However, where possible renewable materials such as wood are used.

In the idea of BIM none of the pictures in this brochure are composed or even retouched. Every imagine of the project in this brochure is taken straight from the model.

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In Summer 2018 the TUM Craft Race at the Starnberger Lake takes place for the first time. The Lake with panoramic views of the Alps is a very popular destination and recreation area for the metropolitan region of Munich. The center for watersports of the ZHS (Zentraler Hochschulsport München) lies perfectly situated close to Starnberg at the north-west end of the lake. Besides activities like Sailing, Windsurfing, Stand-Up-Paddling and Slacklining there is a private lawn for sunbathing with access to the lake for swimming. For the TUM Craft Race interdisciplinary teams from Product design and Sports should design and build their own boats and compete in a race. For this reason the ZHS wants to construct a new boathouse with workshop area to provide space for the students to design and test their prototypes.
**Subject And Task**

**Brief**

- Design a new boathouse and workshop
- About 6 parking spaces for boats of the type 470 „Jolle“ (refer to scheme below)
- Maximum 200sqm workshop area, clearance height 10m
- The building(s) do not need to be next to the water. A carriage can be used to transport the boats
- The parking spaces should be sheltered however the driveway does not need a roof
- Think about good integration within the existing context. Removing old buildings depending on your concept is possible.
Collaboration with Building Information Modeling

Workflow

The workflow was modeled using Business Process Model and Notation (see picture below). The Architect, Engineer, and Project Manager, the institution ZHS and the collaboration platforms Moodle and BIM360 are depicted as swimlanes. In the begining the requirements from ZHS were delivered to the project team using Moodle. Afterwards the project team defined their project standards which were saved on BIM360. In an interactive workflow the project team used BIM 360 as a platform for collaboration and exchange. In the project both the architect and the engineer were allowed to make changes in the model in Revit. Therefore the engineer executed alterations in the architectural model, if the calculation were not satisfying. In the end the architectural model, calculations and quantity take-off were delivered to ZHS using moodle.
Collaboration with Building Information Modeling

Data Exchange and Software Utilization

The model was created in Revit 2018. For the statical calculation Sofistik was used. The project manager executed the clash detection with Solibri Model Checker and the quantity take-off with RIB iTwo. During the project several exchanges took place. The exchange from Revit to Sofistik was accomplished with a plugin. For all other model exchanges the open file format Industry Foundation Classes (IFC) 4 was used. Further informations were exchanged using text messages or PDF-files. The complications that came with the decision to model in Revit 2018 and especially with the data exchange in IFC 4 will be explained in later chapters.
Conceptional Design and Form Finding

The Idea

The building was designed to fit both - its environment and its functional requirements. The surrounding, beautiful lake inspired the idea to create a soft wave shape. The different height requirements set its boundaries: 10m of height are needed to guarantee smooth operating in the workshop, 5m are necessary to store the boats in two layers which is architecturally sound from a space usage point of view, and 8m of height make room for the sailing boats to be dismantled in a dry space in case of an approaching storm. So these are the three fixed points around which the design developed.

Additionally, making way for the mesmerizing view out on the lake was more than tempting. Thus a major glass façade was developed – filling the workshop not only with daylight and also giving the structure a lighter appeal when looked at from the lake, with the water reflecting in its glazing.
Conceptional Design and Form Finding

Form Finding for the Roof

The three fixed points around which the roof shape assembled – 5, 8 and 10 m – can be connected by different kind of mathematical functions. To calculate these functions a Dynamo script was developed which ultimately connected a function for the front of the roof with a function for the back. Thus a surface was created representing what the future roof would look like. Parametric variables made it possible to try out different shapes before finally exporting the roof back into the Revit project. After settling for a specific shape the roof was divided along an even grid in Dynamo with nodes at every intersection point. The un-curved space between 4 of these nodes was therefore equal all over the roof. On each of these spaces, a separate roof element was placed approximating the desired shape. With this approach comes the advantage that all the roof elements are of the same size.
Conceptional Design and Form Finding

Space Concept

We identified two major functions for the project: a working space for sailing boats to be built and repaired and a storage area for six regatta boats. Those two functions were translated into two rooms. Those rooms were then connected by an open space. After different intermediate design stages (see pictures below) the ideal to keep it simple proved itself to be true. The room concept now consists of basic rectangle shapes arranged in a way to guarantee accessibility, comfortability and functionality to the user. The following chapters will shed more light on each of the areas.
Conceptional Design and Form Finding

- WORKSHOP
- BOAT HOUSE
- OPEN SPACE

Dimensions:
- 23.5 m
- 22 m
Architectural Model

The Model
Architectural Model
Architectural Model
Architectural Model

Working Space

The Working Space is divided into two areas, the major working area and a smaller sitting area. The sitting area is on a gallery from where you have an impressive view over the working area to the lake. The gallery creates the possibility of a second exit due to the higher ground level in the western side of the building. The working area is designed in a rectangle shape, so that space usage can be maximised with no interfering building elements or dead corners. The lower part of the facade is constructed wooden framing, thus shelves and can be installed. The main feature of the working space are the huge glass facade facing the lake and the glass facade in the upper part of the northern facade. The latter allows the inrush of pleasant northern light. The working space has beside the exit on the gallery another opening. This opening is a big sliding door to the Open Space for the ships transfer.
Architectural Model

Boat House

The main requirement for the boat house was that it should be able to contain at least six boats. There were two alternatives to fulfill this requirement. Either the boats are placed next to each other on one level or the boats are stacked. The favoured alternative was the latter one, due to the space savings. In the final design the boats are placed in three rows and stacked in two levels. The lifting is done using a motorised cable pull which is mounted on separated steel beams. The connection from the boat house to the open space is a folding door. The intention of installing a folding door is that it creates a big opening while using only little space. Due to the fact that the boat house has no requirements for the insulation that huge opening is not to be considered regarding energy consumption. On the southern side of the boat house is enough space for a shelf for sailing supplies like center boards, rudder, sheets, sails, etc.
Architectural Model

Open Space

The Open Space connects the Boat House, Working Space, Starnberger Lake and the vehicle access. Therefore the main requirement is to provide enough space for rotating the boats including their trailer and possible tug vehicle. This was achieved by reducing the outer construction to one column. Additionally the Open Space provides a rainproof and potential windproof space for dismantling the boats. It was proven that the boats including trailers had enough space for rotation.
Structural Analysis

Structural Concept

The concept is based on a reinforced concrete core, which is important for the stiffness of the building. The beams carrying the roof are supported either by side beams or by reinforced concrete walls. Additionally, three columns carry the steel beams. These columns are executed as reinforced ultra-high-performance concrete (UHPC) columns. The beams, columns and walls all have been optimized during the whole process.

Loads

Given DIN 1055 it is within wind zone 2 and snow zone 1a (585m above average sea level). The building is between 18m and 10m, therefore the basic wind load is 0,8 kN/m². The basic snow load is 1,273 kN/m². For the wind load, wind coming from the lake is the decisive load case. In Revit all the loads, supports and joints had been applied to the model before exporting it to Sofistik for calculation.
Since the design was done using Dynamo, the geometry from the form finding phase could be reused. Boundary curves of the surface and intersections with the walls were derived in Dynamo. These curves then served as basis for the support grid. By using this derivation from existing geometry, the support grid was analytically correct and only a few nodes had to be adjusted manually. Along these curves the outer steel beams were placed forming the roof’s underlying structure. Since Revit roof family objects are no analytical elements, it is not possible to apply depending area loads onto these elements. As a workaround for this problem the loads have been applied as line loads on the underlying support grid, respecting the load entering surfaces. Another problem deriving from this fact was the dead load of the roof construction itself. The components weight was calculated by hand and applied as a line load to the support grid.
Clash Detection

The Clash Detection was done with Solibri Model Checker. The Architecture Model was transferred using the open file format IFC 4. Neglecting the roof the result of the transfer was satisfying (see picture below). For more informations concerning the roof see section „Problems“. Two clashes were found in the model: one wall-wall collision and one beam-wall collision. The informations about the collisions were relayed to the architect for correction, who adapted the model.
As the design process was concluded the Architectural Model was imported into RIB iTWO in order to create a Bill of Quantity. Due to version incompatibilities explained in the next chapter and the fact that there is no free student version of iTWO available, the import into iTWO was executed with the IFC 4 format. However the result was rather satisfying apart from the roof, which will be dealt with in the chapter “IFC-Export of Roof”. The Quantity Take-Off in iTWO was then done using QTO-requests which delivered a Bill of Quantity in the form of a Leistungsverzeichnis. There were only minor issues regarding the glass façade or the topography which could each be easily dealt with.
Problems

Compatibility Revit Versions

Due to the fact that at TU Munich the software products Sofistik, Solibri Model Checker and RIB iTwo and their plug-ins to Revit were installed and available, there was the need to use the computers from the university. The data transfer using the proprietary format .rvt was not possible, since the model was created in Revit 2018 and at TU Munich only Revit 2017 was available. Therefore the model was ex- and imported from Revit 2018 to Revit 2017 using different IFC-Formats.

The result was not satisfying (see pictures below), which is why the data exchange to Solibri Model Checker and RIB iTwo was done using IFC 4 and not the plug-in.
Problems

IFC-Export of Roof

The model was transferred from Revit to Solibri Model Checker and RIB iTwo using IFC 4. In both cases the roof was not available in the destination software product. The assumption after that experience was that the roof was not exported. Therefore the IFC file was opened with the text editor tool and the term „roof“ was searched. The result was that the IfcRoof classes exist in the IFC file. Due to that result there were not any further conclusions done.
Method

After each working session the progress and the effort were evaluated using numbers from one to ten and recorded in an excel sheet. In the end of the project this data was accumulated and diagrams were created (see picture below). It is to mention that the values are very subjective and an inductive method is not very significant with a participation of three persons. Despite of that a trend in the progress and effort can be analysed.

Result

The data provides an overview about the progress and effort relative to the duration of the project. In the beginning most effort was in the coordination part. In the early design phases was a peak concerning the architectural model and concept. Concerning the structural analysis part, progress and effort were quite constant after the early design phase.
Conclusion

During the project only two problems occurred. One problem was because of the incompatibility of different Revit version, the other one due to deficient data exchange with IFC4. As lesson we can take the importance of the knowledge about the software products and the data exchange format in the beginning of a project. The choice of the software products and data exchange can affect the success of the BIM-project. Furthermore it is to mention that the project was small in regard to both building size and project team. For a bigger project it is imaginable, that the collaboration is far more complex, what leads to a higher coordination effort. In summary the project was very successful, what was among others due to the good collaboration within the team.
Impressum

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