



SOFiSTiK



BIM Bridge Engineering Workflow with SOFiSTiK and Revit on a case study of 3 Motorway Bridges on the BAB A3 in Germany

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Abstract. This paper is introducing the new BIM bridge design and analysis workflow using the tools of SOFiSTiK and Autodesk based on some simple case studies. The new SOFiSTiK SBiM (SOFiSTiK Bridge and Infrastructural Modeler) solution allows a design of any kind of bridges, tunnels or other axis-based structures directly in REVIT. This allows a direct generation of any kind of construction drawings, direct generation of 3D reinforcement in the bridge model or with the 2,5D tools of AutoCAD and SOFiCAD. A direct connection to the SOFiSTiK analysis software is available. This new workflow is shown and explained on a case study of three motorway bridges on the BAB A3 between Nuremberg and Regensburg in Germany. The engineering design and analysis of these three bridges was done by HFR Ingenieure from Munich and the construction company was STRABAG. The advantage of the use of a BIM Workflow in bridge engineering is the more effective cost and life cycle management and monitoring by the constructor and client.

Keywords: SOFiSTiK, BIM, Bridge Engineering, SBiM, REVIT, Open BIM.

1 BIM development of SOFiSTiK

Since the beginning of the time of Building Information Modelling (BIM) for the construction industry sector in the early 2000 years, the German developer for high end engineering software solutions SOFiSTiK AG is continuously developing optimized solutions for the engineering BIM workflow. As development partner for Autodesk since 1985, the platform for the SOFiSTiK BIM development is Autodesk Revit.

The aim over these years of strong development effort was - and will be - offering a continuous BIM workflow for structural engineering based on the Autodesk Revit platform. This includes the structures modelling, dimensioning, structural analysis and of course drafting and R/C detailing in one BIM environment. The early years development was focused on the building engineering environment where this process and workflow was implemented in the Revit 2022 version with almost 100%. This can be proven in the seamless operation of building models in Revit with all their

definition of load cases, meshing or special features like construction stages and the seamless integration of the SOFiSTiK FEA (Finite Element Analysis) kernel in the BIM working environment. Additionally, the SOFiSTiK Reinforcement App completes the drafting workflow.

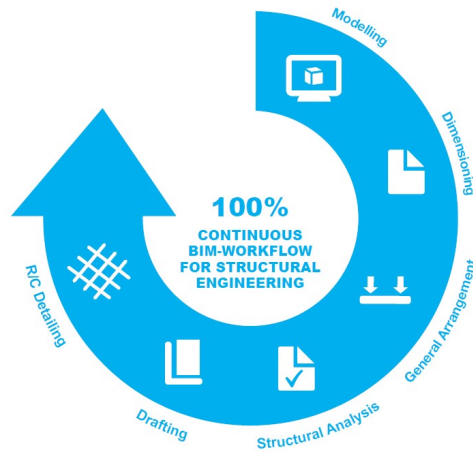


Figure 1: The SOFiSTiK Workflow for BIM in Structural Engineering

Talking about the complex bridge engineering environment, the BIM development started some years later. Taking into account the diversity and complexity of such kind of structures, SOFiSTiK has solved one part of this challenge with the “SOFiSTiK Bridge and Infrastructure Modeler”, called SBIM. It includes a connection to the standard workflow of the SOFiSTiK FEA solutions, to the SOFiSTiK Reinforcement App for Revit and of course also to the 2,5D drafting platform AutoCAD and SOFiCAD. This approach allows a time effective and fast workflow in hybrid system. Depending of the project demands a switch between the new BIM workflow and classical working environment is possible and sometimes recommendable.

1.1 CLOSED vs OPEN BIM for structural engineering

The common definition of a local (Closed) BIM system is if all project co-operation partners are working on one BIM software platform like Autodesk Revit. The advantage in this kind of co-operation between architects, MEP engineering, structural engineers and the construction company is the effectiveness of time and the sharing of data in the same data base and on the same platform. Any information and any process is available at a glance, especially for the client.

In the reality the structural engineers are faced with a lot of different data formats from different projects partners. A so-called Closed (local) BIM workflow based on one software platform is an ideal solution and in practice unfortunately not always adaptable.

To solve this reality data exchange problem the expression Open BIM is gaining over the years more and more importance. An Open BIM solution allows the data

exchange between different software data bases. One of the bases of an open BIM Workflow is the IFC format ^[3] (Industry Foundation Classes), that exists for some decades now. With the help of the building smart association where all important international engineering offices and software manufactures are members, this IFC ^[3] format and the new the SAF (Structural Analysis Format) ^[2] is getting now more and more of importance. This again leads now a seamless integration of an BIM workflow without a common data base on a same software. That is important for an effective work for BIM based structural engineering.

1.2 SOFiSTiK approach

Over the years the SOFiSTiK FEA software solutions were always open to different kind of workflows. This same open-minded approach is now also implemented in the BIM-Workflow, in Bridge Engineering, as well in Building Design. One first step for the Open BIM approach was done years ago with an interface and App for the software RHINO. Over the years the RHINO programming environment called GRASSHOPPER is one of the main effective tools for the connection of SOFiSTiK FE Models with the TEKLA BIM solution or others. The next step is now the direct implementation of an IFC ^[3] connector that allows the im- and export of data bases from other software solutions outside the Autodesk environment.

With the additional implementation of the SAF^[2] format in the SOFiSTiK environment a new option now for an Open-BIM solution is possible. One advantage of the SAF format data exchange is that it's base is on Excel and for this suitable for any kind of exchange without any loss of data base information.

On the other hand, with the integration of the BIM workflow for Building Design and Infrastructure Engineering in Revit, the SOFiSTiK Apps offers also a local BIM workflow in one software environment. Revit development tools like DYNAMO allows in this case additional further developing of routines in the closed BIM.

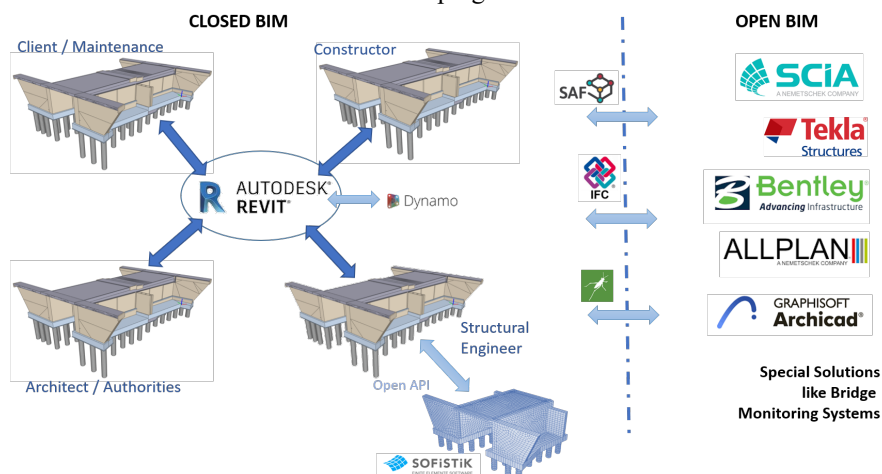


Figure 2: Closed SOFiSTiK + REVIT BIM Workflow with bidirectional options to additional Open BIM Workflows and solutions

2 SOFiSTiK Bridge and Infrastructural Modeler | SBIM ^[1]

Continuously developed and customer driven improved since 2018 on any release of Autodesk Revit the SOFiSTiK Bridge and Infrastructural Modeler is the essential BIM solution solving parametrized infrastructural projects like bridges, tunnels, noise protection walls, retaining walls or other structures. Based on an axis definition, the infrastructure projects can be parametrically defined as native Revit object and used for further BIM processing in the full local BIM workflow. This workflow allows now the use of Revit in conceptual, preliminary and detailed design of the structures and a connection with the SOFiSTiK FE analysis.

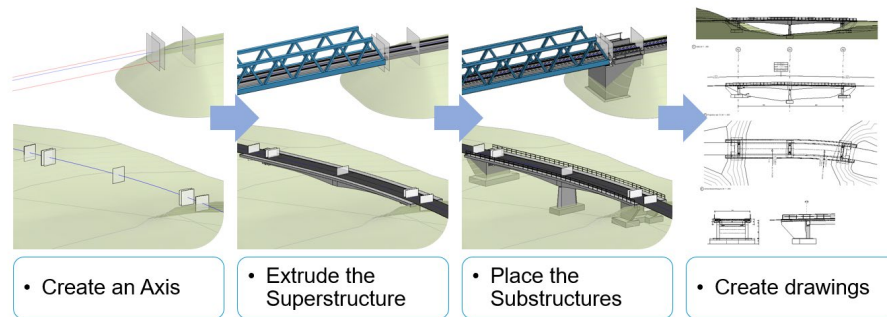


Figure 3: SBIM Workflow for a bridge generation in Revit

3 BIM Case Study: Motorway bridges on the BAB A3 between Nuremberg and Regensburg in Germany

The here explicit chosen examples for the case study are simple. In the complex environment of high-end solutions of large-scale structures done by SOFiSTiK software, they are a little bit the opposite, showing the daily work of structural engineers using the new BIM technology on a demanding geometry with huge time pressure. HFR Ingenieure from Munich is a young and innovative team of structural professionals with high knowledge in engineering and advance experience in all kind of structures.

As a design package of three small motorway bridges on the BAB A3 between Nuremberg and Regensburg in Germany, HFR Ingenieure performed following structures:

- BW446a, replacement of the existing public underpass over a country lane as open frame structure - Length 9.305m, Width 31.60m and Height 4.74m
- BW447a, replacement of the existing public underpass over a country lane as open frame structure - Length 8.70m, Width 32.60m and Height 4.832m
- BW448a replacement of the existing public underpass over a country lane as open frame structure - Length 11.06m, Width 33.158m and Height 4.774m

The client is Die Autobahn GmbH des Bundes, Niederlassung Nordbayern, Nuremberg and the construction company is STRABAG AG. During the initial project meetings STRABAG demanded the need of a 3D BIM design of the three structures in Revit. The reason for this demand is to use the Revit BIM model in further 4D and 5D workflows. In a 4D BIM workflow the Revit model is used to the implementation in the construction time scheduling process. In the 5D BIM workflow the Revit model is used for the accurate cost estimation and forecast of the building costs.

3.1 BW448a

The structure of this overpass is like the following three figures are showing, including a variable axis and two Construction Stages

Ansicht Westseite
M1:100

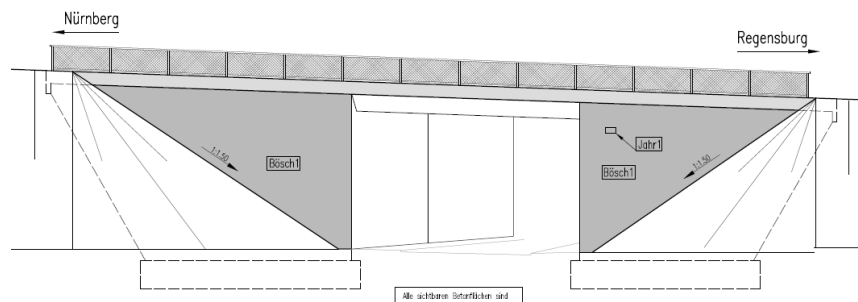


Figure 4: View west side

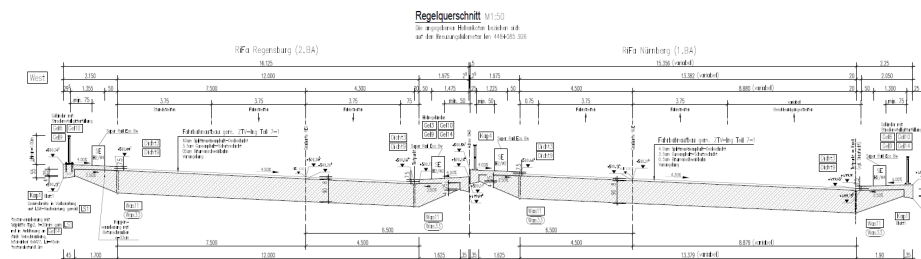


Figure 5: Standard Cross Section

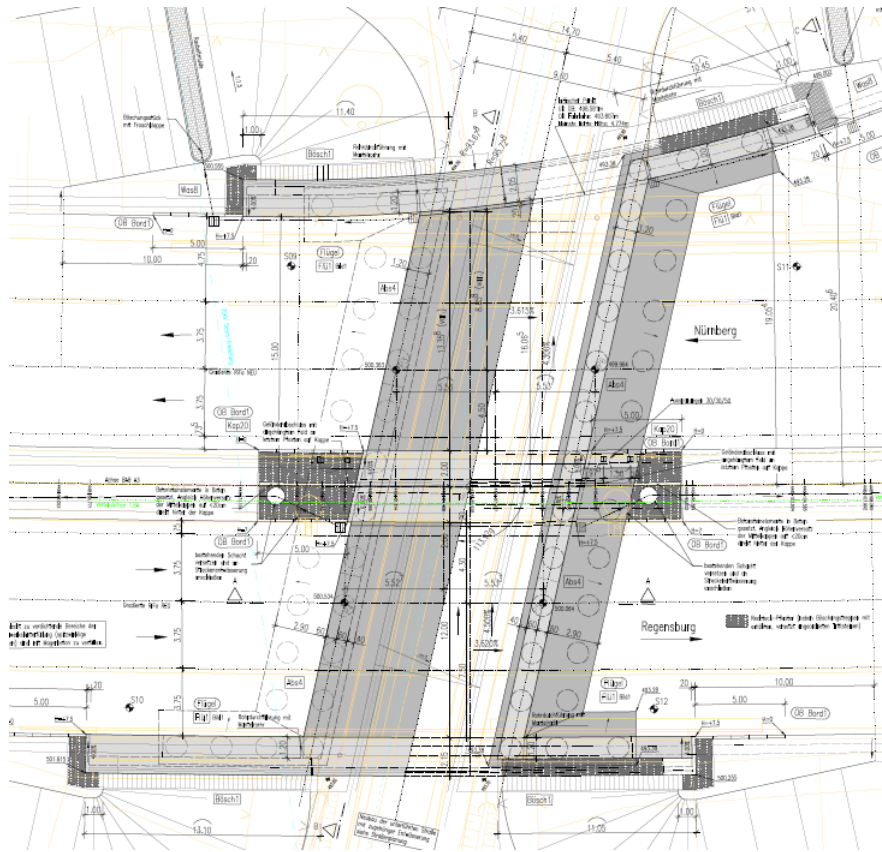


Figure 7: Ground View

To fulfill the demands of the construction company HFR Ingenieure implemented a new BIM Workflow in their design process. The first step is the generation of the structure in Revit with the use of SBIM and additional programming routines in DYNAMO. As next step the structure is analyzed in the SOFiSTiK FE software. Afterwards the construction and formwork drawings are being created directly out of Revit with SBIM. For the reinforcement drawings generation HFR decided to use a hybrid solution. Some smaller complex details are drawn in 3D reinforcement in Revit with the help of the SOFiSTiK Reinforcement App, but the main drawings are done with SOFiCAD in the standard AutoCAD environment. Exporting the drawings directly from SBIM to SOFiCAD was a very effective and time saving solution in the process.

3.2 The following figures are showing the BIM workflow for this bridge

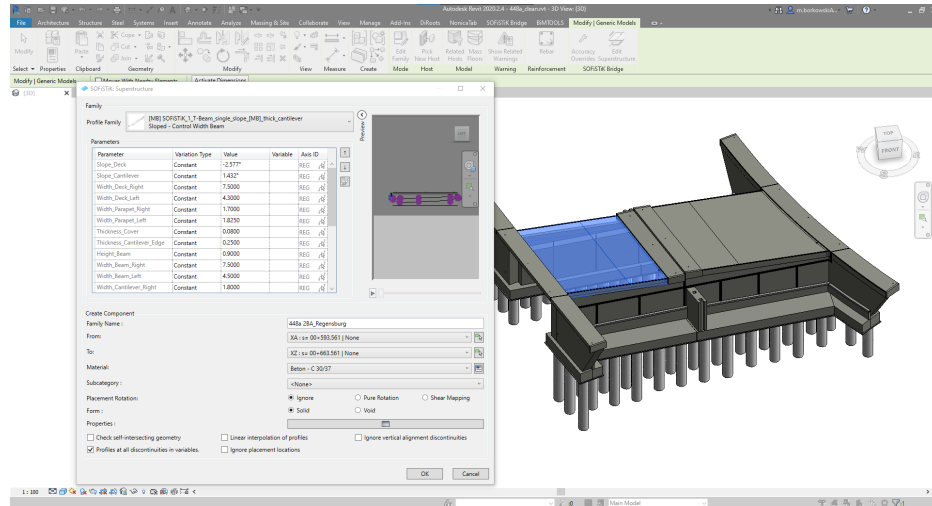


Figure 8: Revit Model of the BW448a with SBIM

As the design team were faced to some problems with some self-joining elements in the stage of modelling, they decided to program some routines in DYNAMO to solve this issue. The abutment is joint by eight wall elements. Due to the complex clothoid geometry a control of the joining order was not possible. The solution was to create an on shape element that solves this problem.

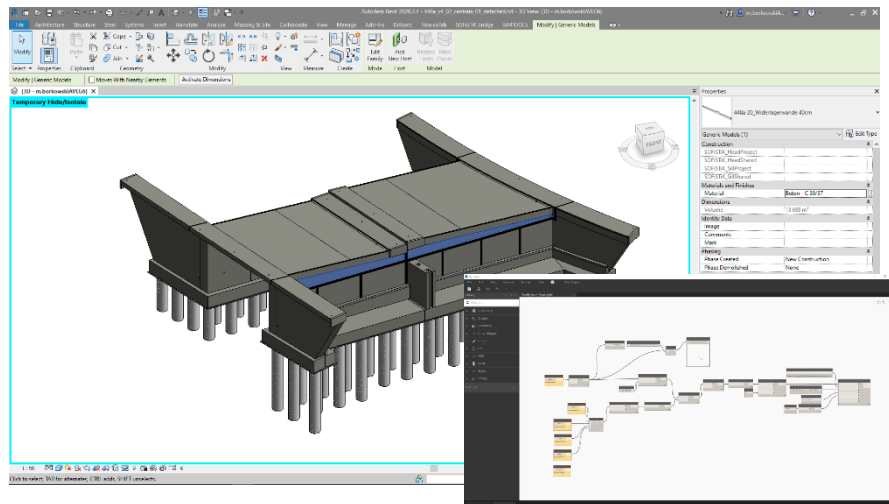


Figure 9: Dynamo routines for joining elements

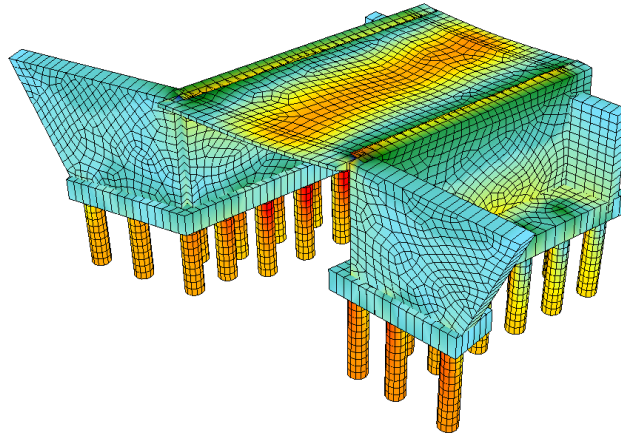


Figure 10: SOFiSTiK FE calculation model of the BW448a in CS1

The construction drawings generated with SBIM were directly exported as PDF drawings. Mostly in 2D, but in some cases as Figure 11 shows as 3D to with the alignment points of the abutment.

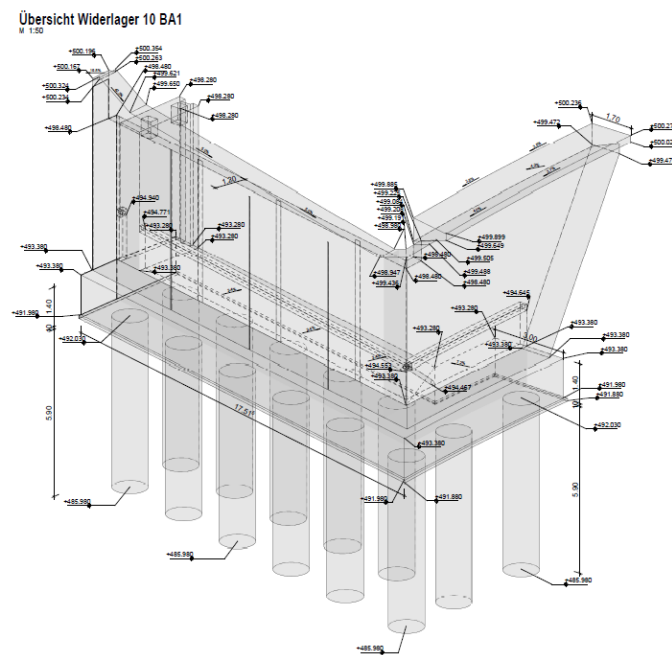


Figure 11: Construction drawing of the alignment point of the abutment out of SBIM

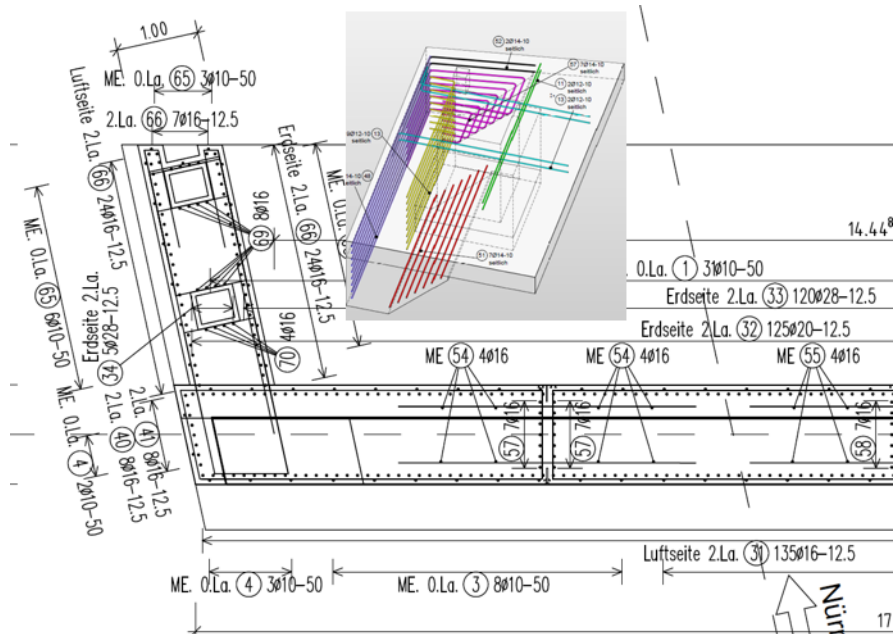


Figure 12: Reinforcement drawings from Revit and SOFiCAD as hybrid solution

4 CONCLUSION

The implementation of the SOFiSTiK BIM Workflow at HFR Ingenieure was a big future step of the office and their design procedure. After the first-time consuming design of the first of the bridges, especially due to the additional programming in DYNAMO, the other two ones were designed faster and more effectively than in the normal so far used standard workflow. Changes applied from to the construction process and adaptation of the FE Model and drawings were done very fast. The use of BIM technology for designers like HFR Ingenieure is definite an improvement. The central model for further processing, like construction process scheduling, costs calculation, lifecycle management or monitoring of a bridge is a huge step towards future effective bridge design technology. This new workflow will be now used for any new bridge design in HFR, especially as the co-operation with SOFiSTiK in implementing this process was very fruit-full. It underlines a very proven and experienced development of the offered design tools by SOFiSTiK.

5 References:

- [1] SOFiSTiK AG; www.sofistik.com
- [2] SAF, Structural Analysis Format; <https://saf.guide>
- [3] IFC (Industry Foundation Classes) building Smart; www.buildingsmart.org/standards/bsi-standards/industry-foundation-classes/