



BIM - Building Information Modeling  
From 3D model to 2D reinforcement drawing

## About the authors



### **Frank Deinzer**

Frank Deinzer is a member of SOFiSTiK's executive board and is responsible for sales and marketing. He holds a Dipl.-Ing. degree in civil engineering from the technical university of Munich. Frank has a strong background in information technology and software engineering and served as head of GUI development and vice president products and marketing before becoming appointed a managing director in 2010. Frank always strives for improvements of the product portfolio's usability and is an enthusiastic innovator with a strong market knowledge. He enjoys street- and mountain-cycling with friends in Franconia as often as his time schedule allows.



### **Armin Dariz**

Armin Dariz is managing director of BiMOTION, a member of the SOFiSTiK group. Armin worked in various positions as structural engineer after graduation from the technical university of Graz. After getting in contact with BIM technology of Revit, he got immediately fascinated and started to explore the potential for such technology in the field of structural engineering. He founded his own company cmotion in 2009 in his hometown Brixen in the Italian alps. Realizing the potential for innovation in this field, he teamed up with SOFiSTiK in 2010 founding BiMOTION. His team oversees all product management and training aspects of SOFiSTiK's BIM activities. Armin lives in Nuremberg with his family and is an avid scuba diver in his spare time.

# From 3D model to 2D reinforcement drawing

How BIM technology enables a seamless workflow all the way from the 3D model and structural analysis through to 2D reinforcement drawings.

Despite the fact that 3D planning is practically standard practice these days, the industry still relies on 2D reinforcement drawings for use at the construction-site. This article describes the tools and methods used in the past, current technologies and workflows, and developments we may see in the future.

SOFiSTiK AG has been developing CAD-based applications and other software for structural engineering with a focus on reinforced concrete detailing for over 25 years. New technologies are now creating opportunities to improve the planning process. In addition to tried-and-true CAD applications, SOFiSTiK also develops software solutions that support 100% seamless BIM workflows for building planning. BIM promises to deliver vastly enhanced planning quality and reliability compared to previous approaches.

## Current non-BIM planning methods

Before the PC era, construction documents were generated manually. Each party in the planning process generated its own documents, which were then exchanged and coordinated among everyone involved. The documents comprised two-dimensional drawings such as floor plans, sectional views, and elevations (figure 1)

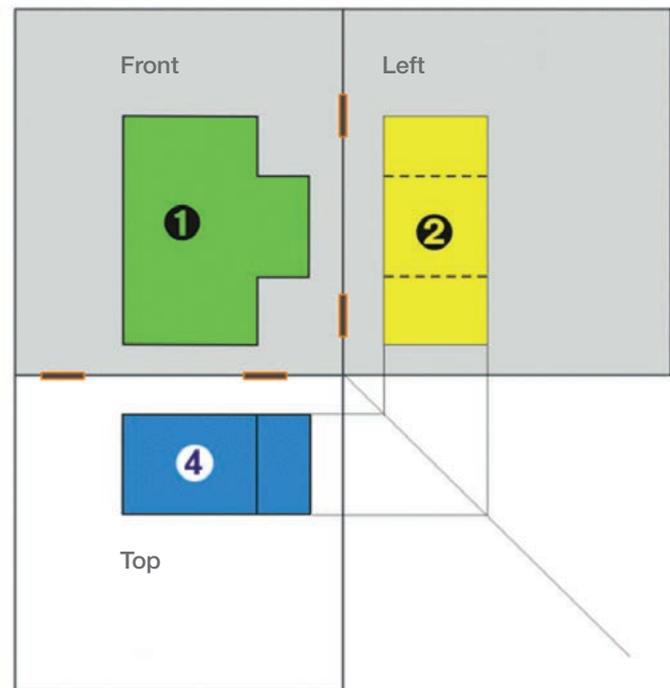


Figure 1. Orthographic projection in 2D

The advent of CAD systems did nothing to alter this workflow. The only difference was that the information was then exchanged digitally instead of on paper. Although this does make it easier to store information and

modify plans, the individual drawings are still not linked to one another in any way. That means a modification to one structural element still involves making changes across multiple drawings. One and the same element is thus represented not only within different views (floor plans, sections, elevations), but also across different disciplines such as architectural planning, reinforcement detailing, general arrangement, structural analysis etc. in individual drawings. Each participant in the planning process has their own set of drawings, which must be manually updated across each and every view whenever a change is made.

Coordinating changes, especially when they occur frequently, can thus become an enormous challenge requiring considerable discipline and precision. Errors and discrepancies still find their way into planning information, regardless of how much care is taken to avoid them.

State-of-the-art CAD systems have, however, started to offer some assistance here. Dependencies between drawings can now be defined, and in some cases database links are supported. Yet despite all these improvements, it remains practically impossible to store building information in CAD systems with the consistency needed to completely eliminate errors.

A solution to this complex problem is now possible thanks to object-oriented databases. They allow elements to be stored together with the corresponding structural information within a three-dimensional space. This means not only geometrical data such as wall

**Autodesk Revit provides the foundation for fully parametric object-oriented 3D building information modeling.**

profiles, sections, columns, and story heights is stored electronically, but everything required to build the

structure including information for individual trades, costs, logistics details and more is associated with the corresponding building component. This technology is essential for enabling BIM workflows.



Figure 2. Structural engineering workflow

### ‘Big BIM’ vs. ‘Little BIM’

Everyone involved in the planning will ideally be working on the same information model, with changes made directly in the common database. This of course can only work with a coordinated approach and the corresponding software, such as Autodesk Revit together with the corresponding add-on applications.

The 2D plans in this model are filtered representations generated from the database and thus current at all times, no matter who has modified the 3D model. It’s possible to construct the model in such a manner that multiple stakeholders in the planning process are gran-



Level 0



Level 1 - Lonely BIM



Level 2 - Little BIM



Level 3 - Big BIM

**Figure 3.** BIM implementation levels

ted access permissions and can work simultaneously on the same model stored in the database. Implementing this method requires that all the planning stakeholders are capable of using the respective software and that everyone who is involved accepts and actively supports the unique perspectives of all the participants in the process.

This type of BIM workflow (level 3: Big BIM, figure 3) can require planning departments to adopt different organizational structures than those required by conventional methods. The spheres of responsibility of designers and engineers are no longer clearly delineated. Consequently, achieving a comprehensive BIM workflow is best pursued one step at a time.

In the next section, we will examine a BIM workflow for structural engineers at level 1. Other participants can then be integrated into the overarching multidisciplinary workflow at a later time. This also reflects the way BIM is currently being implemented in the United Kingdom. This level of BIM has been referred to as “Little BIM”.

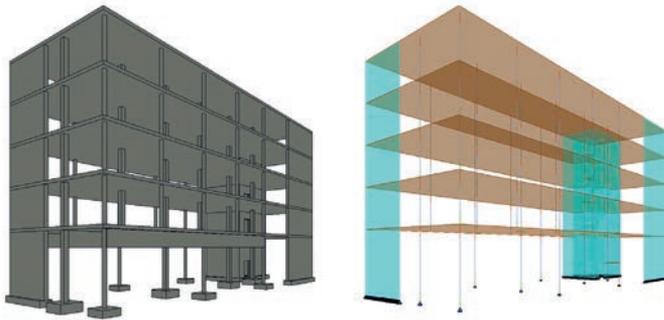
Companies that can provide services across multiple disciplines are at a clear advantage. They can reach level 3, or ‘Big BIM,’ more rapidly since acceptance across the various disciplines normally already exists.

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## BIM for structural engineering (Little BIM)

The main responsibilities of a structural engineer are to generate formwork drawings for reinforced concrete structures, draft structural drawings and arrangement drawings for steel and wooden structures, conduct structural analyses, and create final shop drawings for steel construction and reinforcement drawings for concrete work. In this section, these steps are described using a reinforced concrete frame structure as an example. The first step is to model the structure.

Autodesk Revit offers very powerful modeling capabilities and automatically generates an analytical model in the process of building the geometric model (figure 4).



**Figure 4.** Geometric vs. analytical model

This analytical model can be modified within certain tolerances by the user as required — without changing the geometric model. Having these two models of the construction project stored in a database allows plans and dimensions to be derived from the geometric model while providing the ability to generate an FE model from the analytical model.

SOFiSTiK BIMTOOLS aid users in generating and editing floor plans, sections, views, and schedules for formwork drafting and general arrangement based on the geometric model.

The BIMTOOLS are currently available as free SOFiSTiK app via Autodesk Exchange Apps at <https://apps.exchange.autodesk.com/RVT/en/Home/>

To export an FE model, the structural engineer now adds any missing analytical objects such as bearings, loads, or links.

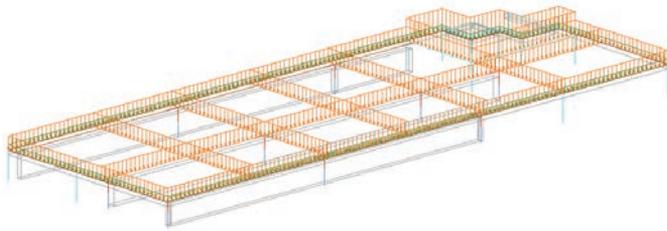
**Revit allows for a modification of the analytical model without necessarily changing the geometric representation.**

SOFiSTiK FEA Extensions for Autodesk Revit (included with SOFiSTiK's FEA software) add seamless integration of FE analysis with the entire range of SOFiSTiK features. Fully automated FE mesh generation with one of the most powerful 3D mesh generators available is initiated directly in Autodesk Revit, allowing system changes to be quickly implemented as structural analysis models. Another important consideration in this context is the allocation of information about materials, sections, and actions via what are known as mapping tables. Thus allowing full control of all simulation aspects and details to the responsible engineer.

The interface offers two options for exporting the analytical model to the SOFiSTiK database:

1. Export of the entire system with all accompanying loads and actions for global verifications such as load transfer or dynamic analysis of the system as a whole.
2. Export of one or more subsystems for component analyses or checks of structural members. This option allows subsystems such as floor slabs to be extracted and verified separately (figure 5).

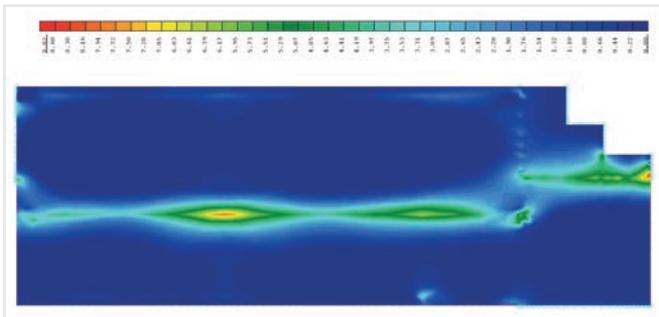
The main challenge when exporting subsystems lies in the fact that these subsystems initially have no



**Figure 5.** Floor slab subsystem with distributed live loads

boundary conditions. That's why the SOFiSTiK solution checks all the objects in the entire system for connections to the subsystem when exporting. Elastic or rigid boundary conditions as appropriate for the respective subsystem are automatically determined by the software through analysis of the attached supporting elements such as columns or walls. This makes it possible to generate subsystem support conditions that match the full model — while maintaining the ability to analyze subsystems separately.

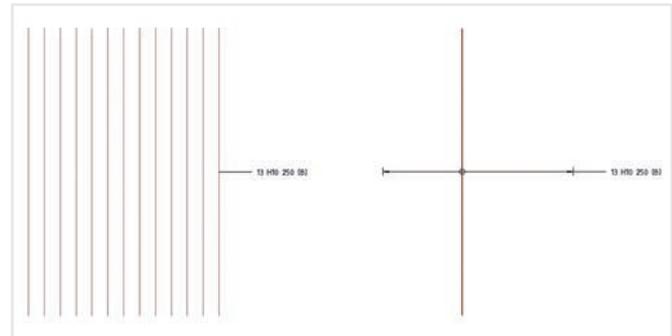
The interface provides other features as well, such as the ability to distribute surface loads across a floor in a checkerboard pattern for structural component dimensioning in compliance with applicable standards. Once the analysis and dimensioning of the system or subsystem is complete, you can use the results to generate reinforcement drawings (figure 6).



**Figure 6.** Required reinforcement in cm<sup>2</sup>/m; upper layer in major direction

## Performing 3D R/C detailing to generate 2D drawings including rebar and bending schedules

Generating reinforcement drawings has been one of the biggest challenges for software developers within the context of the new developments described above. In contrast to formwork drawings, reinforcement drawings are not derived directly from the 3D model, but rather represent it with symbols instead. We have created a linear arrangement of reinforcement bars (figure 7) for illustration purposes.



**Figure 7.** Real (left) vs. symbolic (right) depiction of reinforcements in the 2D drawing

In a 2D reinforcement drawing, bars are normally represented by a distribution line that is depicted as just a single rod together with information such as the number, diameter, spacing, etc. of the actual rods.

Another difficulty is that different symbols are used in different regions of the world to represent the same reinforcements (as evidenced by the regional variation in representing reinforcement layers, for instance).

The first step of the reinforcement detailing process involves generating the 3D model. The user does not have to worry about position numbers at this point.

Which reinforcements will later appear on which plans can also be decided at a later time. There are a number of ways to generate this 3D reinforcement model in Autodesk Revit:

- + Full manual generation with the assistance of onboard reinforcement tools.
- + Use of add-ons such as Autodesk Revit Extensions. These extensions allow reinforcement elements for standardized components to be simply and efficiently generated via parameters such as the number, diameter, spacing, etc.
- + Automated generation of proposed 3D reinforcement layout with the assistance of SOFiSTiK Reinforcement Generation (available via Autodesk Exchange Apps). This recently-launched tool initially appeared as a “Labs” version. It reads dimensioning results from the SOFiSTiK database or Results Packages and generates a reinforcement layout based on rules users can adjust themselves. The proposed layout is an ideal way to ensure the required structural reinforcement is used. The module also assists in verifying manually generated reinforcements or automatically generated reinforcements that were subsequently modified. This gives structural engineers the ability to compare the reinforcements used in the virtual building model with structural requirements during any phase of the project. Secondary reinforcements, such as those used around openings in floor slabs, are not generated by this module but can be added manually by the user.

Subsequently, the 3D reinforcement model is used to generate the corresponding 2D reinforcement plans. SOFiSTiK Reinforcement Detailing supports this part of the process (figure 8).

The module is available from SOFiSTiK or as a 30-day trial version from Autodesk Exchange Apps <https://apps.exchange.autodesk.com/RVT/en/Home/>.

At the beginning of the workflow, the components including their corresponding reinforcements are allocated to the respective drawings. This allows the software to add bar marks to the individual plans, taking into account the respective geometries and materials. Subsequently, the corresponding labeling elements are removed, the symbolic representations for installation work are generated and, if necessary, the shape handles are removed from the components.

**SOFiSTiK Reinforcement Detailing significantly accelerates the creation of 2D reinforcement sheets out of 3D models.**

Now, all that is missing are the rebar and bending schedules. The program generates them fully automatically and they can then be placed directly on the plan if required (figure 9).

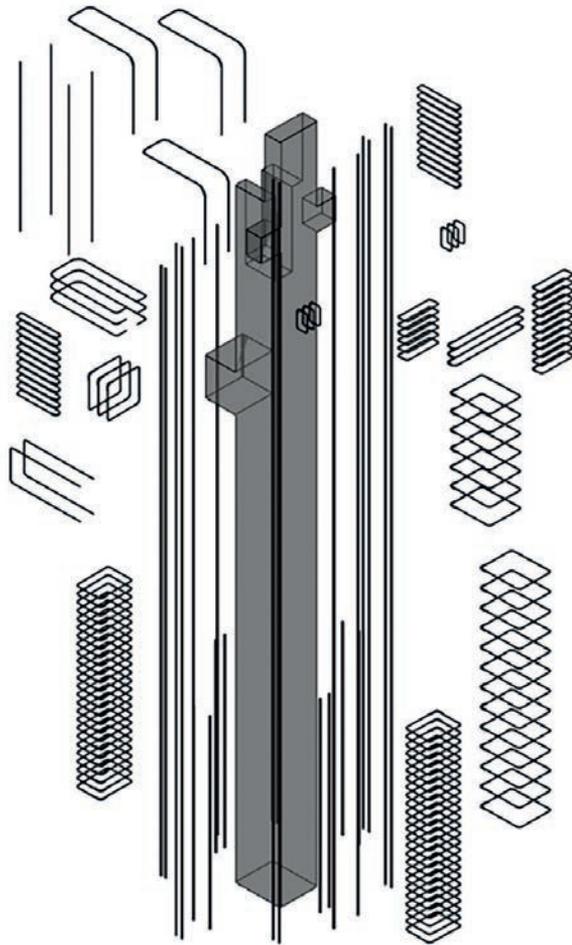
## A look towards the future

The BIM methodology, for instance, leads to the tasks performed by design engineers and civil engineers to



Figure 8. SOFiSTiK Reinforcement Detailing as an Autodesk app





**Figure 10.** 3D-pdf, exploded-view drawing  
(image: BIMOTION / SOFiSTiK)

Using new tools and technologies always presents an opportunity to question and optimize established workflows. Some companies may even find organizational restructuring beneficial in order to provide optimal support for new processes.

All of these visions and innovative ideas or technologies have one thing in common: the potential to achieve a quantum leap in efficiency.

## Final comments

The BIM workflow for R/C detailing described in this article is perfectly suitable for many building construction projects. Its use in civil engineering projects is also very feasible for projects that involve walls, floors, supports, and beams with geometries similar to those seen in buildings. Autodesk and SOFiSTiK AG will continue working together to close any remaining gaps in the system's functionality. Then the workflow described here will also be applicable to complex geometries such as those found in beam bridges.

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Armin Dariz, BiMOTION GmbH

### Additional information:

[www.sofistik.com](http://www.sofistik.com)  
[www.bimotion.de](http://www.bimotion.de)  
[www.youtube.com/user/SOFiSTiKAG](https://www.youtube.com/user/SOFiSTiKAG)



Project: 5\* and 6\* Lusail Katara Hotel, Doha (Qatar)  
General planning: Kling Consult Consultancy for Design and Civil Engineering  
Client: Katara Hospitality, Doha (Qatar)  
Software: Autodesk Revit Structure, SOFISTiK FEM Software

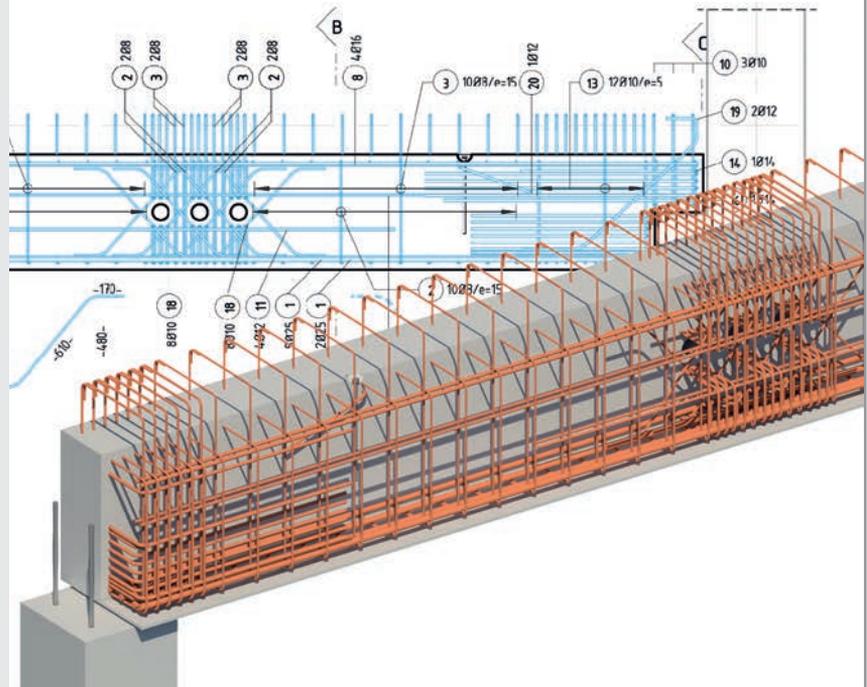


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