Federal Ministry
for Digital
and Transport

Federal Trunk Roads BIM Masterplan

Framework document: Model-based plan derivation for bridge design - version 1.0

Contents

Overview of the Framework documents

This Framework document on model-based plan derivation for bridge design is part of the model guideline for BIM (MG BIM). The MG BIM framework documents define the uniform application of the BIM method and support the implementation strategy explained in the Federal Trunk Roads BIM Masterplan. They provide practically focused answers on the BIM-specific topics and issues that are necessary for a uniform understanding of BIM throughout Germany in the federal trunk roads sector.

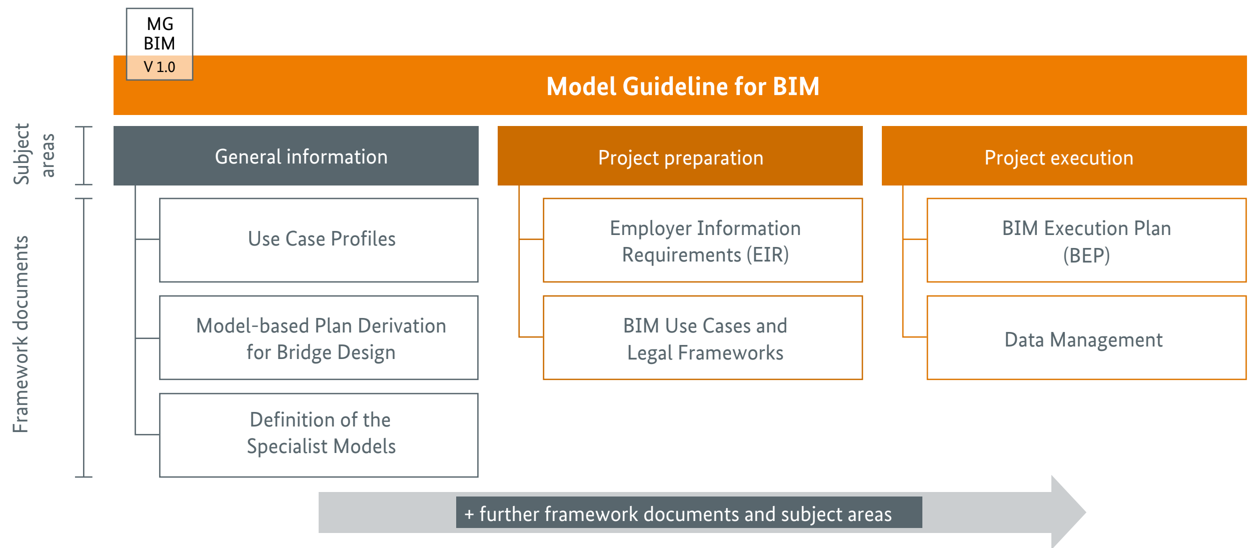
The version 1.0 framework documents were designed to facilitate updating to a new version of the model guideline for BIM at the beginning of phase II of the BIM implementation strategy; the same will apply again later for phase III. Finally, the documents will be transitioned to the model BIM guideline for the standard process.

Framework documents are developed by the expert groups initiated by the Federal Ministry of Transport and Digital Infrastructure and in the expert groups established at the official talks of the Federal Government and the federal states on BIM. In these groups, various technical experts consisting of employees of the Federal Ministry of Transport and Digital Infrastructure, the Federal Highway Authority, Autobahn GmbH, German Unity Planning and Construction Company for Trunk Roads (DEGES), the federal state authorities with delegated powers, the Federal Highway Research Institute (BASt) and the Road and Transport Research Association (FGSV) are working with BIM Germany on the ongoing progress of the BIM implementation strategy for federal trunk roads. The lessons learned from completed and ongoing projects, the proven BIM4INFRA2020 toolkits and the input from the continuous participation of all stakeholders were taken into account. At the same time, the general developments in the BIM method were considered for national and international standardization.

As a result, the documents mirror the respective state of the art and progress in standardization. Reflecting these increasing knowledge levels, the framework documents replace the thematically identical parts of the BIM4INFRA2020 toolkits and should be construed as recommendations for future projects and for a potential adaptation of various standards and guidelines.

Each framework document is assigned to a thematic category based on the project process and is thematically self-contained. Cross-references to other framework documents are explicitly highlighted. Further information on the framework documents can be found in the document ‘Explanation of the framework documents’.

Version 1.0 of the model guideline for BIM comprises the documents shown in the figure.



Outline

This framework document is aimed at all users of the BIM method who are responsible for processing design drafts for engineering structures.

The existing conventions set out in the Guidelines for Drawing up Design Drafts for Engineering Structures (RAB-ING) cannot simply be applied to a model-based approach. The approach of visualizing the engineering structure in a geometrically idealized way while using as few plans as possible, as is common in the conventional presentation as a two-dimensional construction, cannot be adopted when doing model-based planning with the BIM method. Deriving plans from the model produces other geometrically exact visualizations and requires deviating conventions. This framework document addresses this aspect. The document describes the following key aspects:

- Presentation of the existing conventions to document design drafts for engineering structures (RAB-ING).
- Description of the technical bases for deriving plans from a building model
- Obstacles of existing conventions in model-based approaches
- Alternative forms of presentation and supplementing existing conventions
- Recommendations for model-based plan derivation for engineering structures
- Illustration of the recommendations based on model example 6-2-1 ‘Overpass structures – farm tracks’ of RAB-ING

The document is considered a recommendation for deriving plans for bridge structure drafts when the BIM method is used. It presents alternative forms of visualization and specific recommendations for drawing up model-based design drafts, which are to be agreed separately as a documentation requirement in addition to RAB-ING for BIM projects.

1. Introduction

Different standards and guidelines have to be considered when planning, building and operating federal trunk road infrastructure. When it comes to bridge construction and civil engineering, the regulations issued by the Federal Highway Research Institute (BASt) are particularly relevant. These address the design, the construction as well as the structural maintenance of the federal trunk roads [1]. In addition to content-related and technical conventions, the Guidelines for Drawing up Design Drafts for Engineering Structures (RAB-ING) [2] summarize essential aspects on the construction project and the design documents. These feature, for instance, requirements for the explanatory reports, cost calculation, structural plans and structural analysis for the design phase of bridge construction and civil engineering projects.

The requirements laid down in RAB-ING have to be questioned when Building Information Modelling (BIM) is applied and be amended for a three-dimensional model-oriented design approach. A digital building model requires a significantly different approach for drawing up structural plans. The technical drawings are no longer created as isolated 2D presentations, but are mainly derived from 3D models. The software products for modelling structures have corresponding functionalities. Here, the technical implementation differs in many ways from the familiar approach of working with two-dimensional structures. The visualizations used here are based on the requirements of drawing up plans manually with the objective of documenting the structure with as few drawing elements and plans as possible. Against this background, the existing guidelines use geometrically idealized forms of visualization rather than exact ones. They describe the construction of the engineering structure in terms of elevation, ground plan and section in a simplified and consolidated way. However, this fundamental documentation concept should be considered invalid with plan derivation, as the drawing elements are derived from the digital building model and are therefore inherently exact. Therefore, idealized visualizations should be avoided and documentation in a larger number of sections and elevations as well as plans should be preferred.

This framework document addresses changes in the process of drawing up plans that result from using a digital 3D model with the BIM method. For the documentation of a model-based design draft, an alternative visualization form will be presented. As a start, the existing requirements for the preparation of design plans of engineering structures in accordance with RAB-ING will be compiled in the following. Subsequently, the technical bases for model-based plan derivation and the corresponding obstacles that are due to currently applicable documentation requirements will be explained. As a result, recommendations for plan derivation in projects involving the construction of new bridges are compiled and implemented on the basis of model example 6-2-1 ‘Overpass structures – farm tracks’ [3].

2. Existing convention for drawing up plans

The Guidelines for Drawing up Design Drafts for Engineering Structures (RAB-ING) are made up of six parts:

- Part 1: General information
- Part 2: Structure and content of the explanatory report
- Part 3: Preparing the cost calculation
- Part 4: Preparing the structural plan
- Part 5: Structural analysis for the design phase
- Part 6: Model examples

In the context of this framework document, parts 4 and 6 are above all relevant. Part 4 addresses the general form and content of structural plans. It distinguishes between the following:

- Section 1: Construction of new bridges
- Section 2: Repair and strengthening works on bridges
- Section 3: Construction of replacement bridges
- Section 4: Construction and conversion of cut-and-cover tunnels
- Section 5: Construction and conversion of bored tunnels
- Section 6: Noise abatement walls and similar protective walls
- Section 7: Gantries

For the different construction projects as well as structure typologies, part 6 of RAB-ING contains model examples for implementation that illustrate the rules laid down in part 4 by giving practical examples.

Given the number of construction works and different structure types it describes, this document cannot include them all. Therefore, this framework document focuses on new bridge structures (part 4 – section 1). However, some contents of the following sections can also be adapted for other works and structure types.

2.1 Plan contents and requirements

For the construction of new bridges, the chosen draft solution is to be presented in a clearly structured form. The following technical drawings of the structure have to be made:

- Elevation
- Longitudinal section
- Ground plan
- Standard cross section
- Cross sections
- Structural details

Furthermore, the title block and the essential structure data, the construction material information, soil parameters as well as information on supports, expansion joints and distribution of material in accordance with the RAB-ING templates have to be included in the plans as a legend.

Generally, one single plan is not sufficient to reflect the entire design draft. Therefore, the visualizations are spread over several plans, depending on their size and complexity. Usually, the elevation of the structure, the longitudinal section as well as the ground plan are arranged one above the other in a layout plan. The following plans serve to illustrate the standard cross section of the superstructure and further characteristic cross sections perpendicular to the bridge axis as well as structural details. In the following Table 1, the most important conventions for the different visualizations are briefly outlined. The detailed description of the form and contents can be found in Part 4, section 1 of the RAB-ING.

Table 1: Conventions of the RAB-ING for the different visualizations for the construction of new bridges

Visualization	**Conventions**
Elevation	▪ Generally, on a 1:100 scale (1:50 for smaller structures and 1:200 or smaller for large structures) ▪ For straight or skew bridges, terrain section parallel to the bridge axis; for curved structures, straight terrain section that is functionally tangent to the bridge axis. ▪ Parallel projection perpendicular to section
Longitudinal section	▪ To be placed below the view on the same scale ▪ For one-piece superstructures, section to be made in the axis of the structure; for two- or more-piece superstructures along the gradient ▪ To be continued at least 5 m behind the end of the wing wall by the earth body; wing walls concealed behind the earth body are to be sketched as hidden lines ▪ For skew bridges, abutments and piers, including the foundations; the section is at a right angle to the substructure axis; overlap with longitudinal section of the gradient ▪ Visualization of soil profiles from the geotechnical opinion ▪ Detailed list of elements and requirements to be visualized, see RAB-ING, Part 4, section 1
Ground plan	▪ To be placed below the longitudinal section, in general, on the same scale ▪ Surrounding terrain is to be visualized ▪ Visualization of one half of the bridge with top view of the superstructure, the other half with top view of the substructures with the superstructure lifted or opened and abutments without backfilling ▪ Detailed list of elements and requirements to be visualized, see RAB-ING, Part 4, section 1
Standard cross section	▪ Standard cross section of the superstructure on a scale of 1:50; possibly smaller for wider structures ▪ Section at right angle to bridge axis ▪ Detailed list of elements and requirements to be visualized, see RAB-ING, Part 4, section 1

Cross sections	▪ Characteristic cross sections to clearly describe the structure
	▪ Section at right angle to bridge axis
	▪ Visualization that includes substructures and foundations as well as surrounding terrain
	▪ In general, the following elements have to visualized:
	  ▪ Cross section of the earth body at the end of the wing wall facing the abutment
	  ▪ Cross section of the superstructure in front of the abutment looking at the abutment
	  ▪ Cross section of the superstructure facing the piers
	  ▪ Characteristic horizontal sections of the piers

Structural details	▪ The pier heads and arrangement of bearings have to be depicted in the drawings ▪ If necessary for the description of the structure, structural details are to be visualized (such as accessibility of components, joint design, bridge equipment)

2.2 Conventional approach with two-dimensional structure

To date, plans for engineering structures have been drawn up as two-dimensional structures via Computer-Aided Design (CAD). The corresponding elevations, ground plans, sections and details of the engineering structures are drawn up with CAD software and are placed in the relevant plan layout.

The drawing objects are structured by means of layers. These generally determine the graphical characteristics of the drawing objects and their visibility. Often, CAD guidelines or layer conventions that companies, contractors or contracting entities apply as standards have to be considered when construction drawings are created.

3. Model-based plan derivation

With Building Information Modelling (BIM), a new methodology for planning, constructing, operating and maintaining structures is establishing itself. This also impacts the way design drafts are produced. As part of the BIM process, digital building information models are created. The structure plans are no longer created as isolated two-dimensional designs, but are directly derived from the 3D model. Deriving the plans ensures consistency between the model and plans and also prevents conflicts between plan visualizations (for instance regarding sections and ground plans). Doing so incorporates key advantages of the BIM method in a practical approach based on the Road Map for Digital Design and Construction [4] (avoiding planning errors, consistent planning).

3.1 Technical basics

Structures are modelled with BIM capable authoring software. In general, this is implemented by means of parametric object-oriented modelling approaches [5]. Here, models are created based on key geometric boundary conditions (primary and secondary axes, gradients, positioning, crossfall etc.). Changes to these boundary conditions automatically change the dependent geometry.

The modelling software provides tools to generate elevations, ground plans and sections. The plan visualizations derived from the model are associative in many software applications. Changes to the model are automatically transferred to the geometry mapped in the plans. Elevations of the structure can be produced as orthogonal or perspective projections from any angle. Ground plans of the structure are created along a defined horizontal plane with a defined depth of view. The same applies to sections of the structure. These are created along a straight section plane with a defined section depth (see Figure 1).

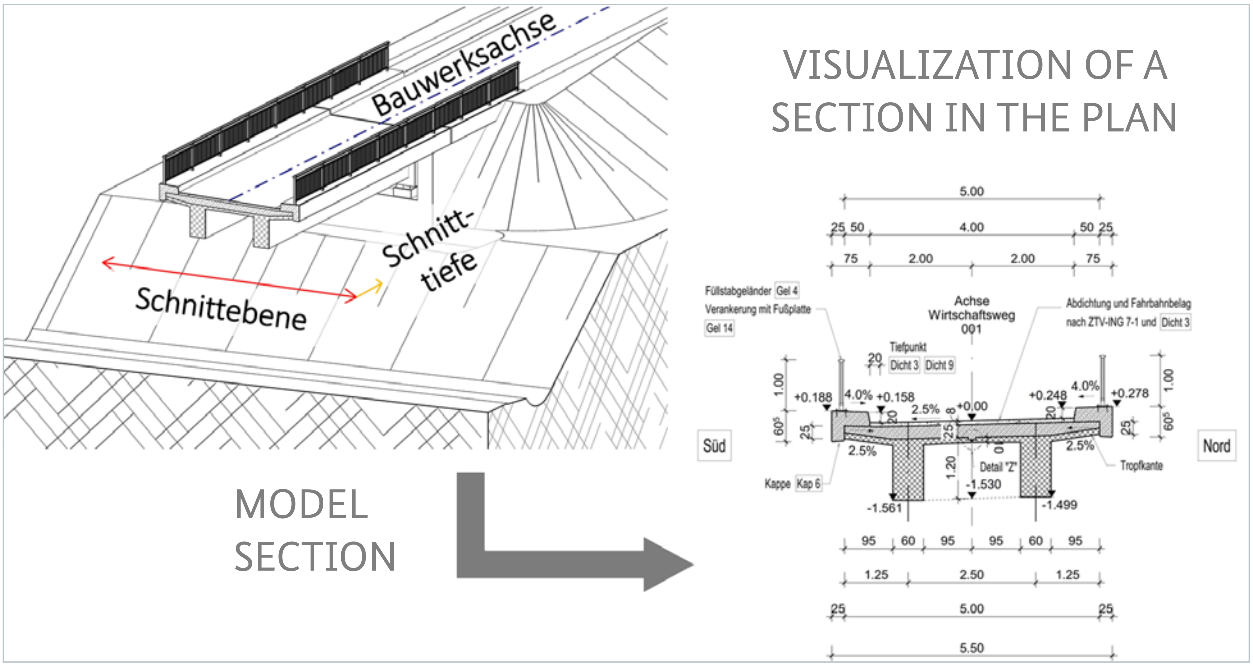


Figure 1: Principle for deriving a section from the model (© Schüßler Plan) „Technical descriptions partially in German“

These are geometrically exact representations. The plan visualization shows all edges of the cut objects as well as objects that are within the defined section depth. Since the objects in the model are represented as solids, section surface samples are shown for the components cut in the section plane depending on the graphics settings for objects.

In the context of curved structures (arch or clothoid in the axis of the structure and/or slope or crest and sag along the gradient), an exact geometric representation means that clear visualizations can only be produced when the section depth is zero or approximately zero. Otherwise, the curved edges of the structure that are within the defined section depth are represented as three-dimensional objects. The resulting visualization (see Figure 2) deviates from the idealized visualization forms shown in RAB-ING (see Figure 3).

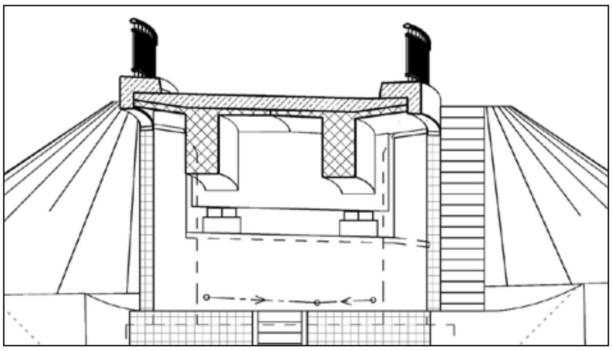


Figure 2: Geometrically exact visualization of a section derived from the model (© Schüßler Plan)

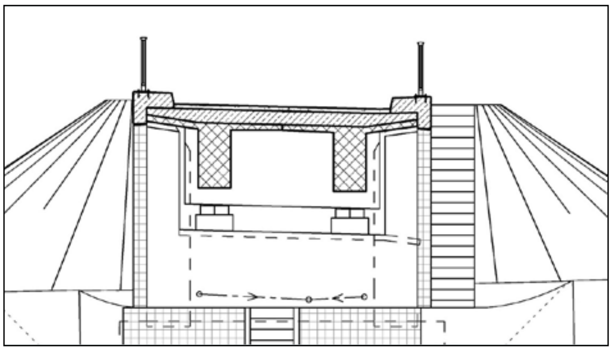


Figure 3: Geometrically idealized visualization of a section in accordance with existing conventions (© Schüßler Plan)

Subsequently, dimensions and labels are added to the visualizations derived from the model, and placed in the plan layouts. This shows the key design characteristics and geometric dimensions. Since the models not only include the geometry itself, but also a whole range of object-related information and data (semantics), the components can be given smart labels in particular. They read out the alphanumeric component information stored in the model and reference it in the label objects.

3.2 Processes of modelling and plan derivation

The process of drawing up structural plans changes when the BIM methodology is used. It differs from the conventional approach with two-dimensional structures described in section 2.2, which leads directly to the preparation of technical 2D drawings. In the model-based approach, the process is basically broken down into the following two steps:

- Modelling of the structure
- Plan derivation from the model

Even though it is easy to derive plan visualizations and these are often associatively connected with the model, it makes sense to only produce visualizations with finalized labels and dimensions after the modelling process has been concluded. The models have to be checked for clashes before plan derivation so that the plans are derived based on geometrically consistent models. Therefore, in the course of the design process, it is necessary to coordinate the geometry of the models with the contracting authority and have it confirm the current form before plans are derived.

Usually, the derived visualizations have to be edited with the authoring software. This includes, for instance, controlling the visibility of individual objects, overwriting the graphics of lines and patterns or supplementing visualizations with structural details and detailed elements that are not subject of the modelling process. Adjusting the model can in some cases require recreating references and dependencies of labels and dimensions and adjustment of previous edits.

As a result, coordination on geometric drawings, especially in early project phases, is mainly carried out on the basis of building models. Plans are not exchanged and coordinated on this basis until the end of the service phase.

The individual steps described above are presented as a showcase in Figure 4.

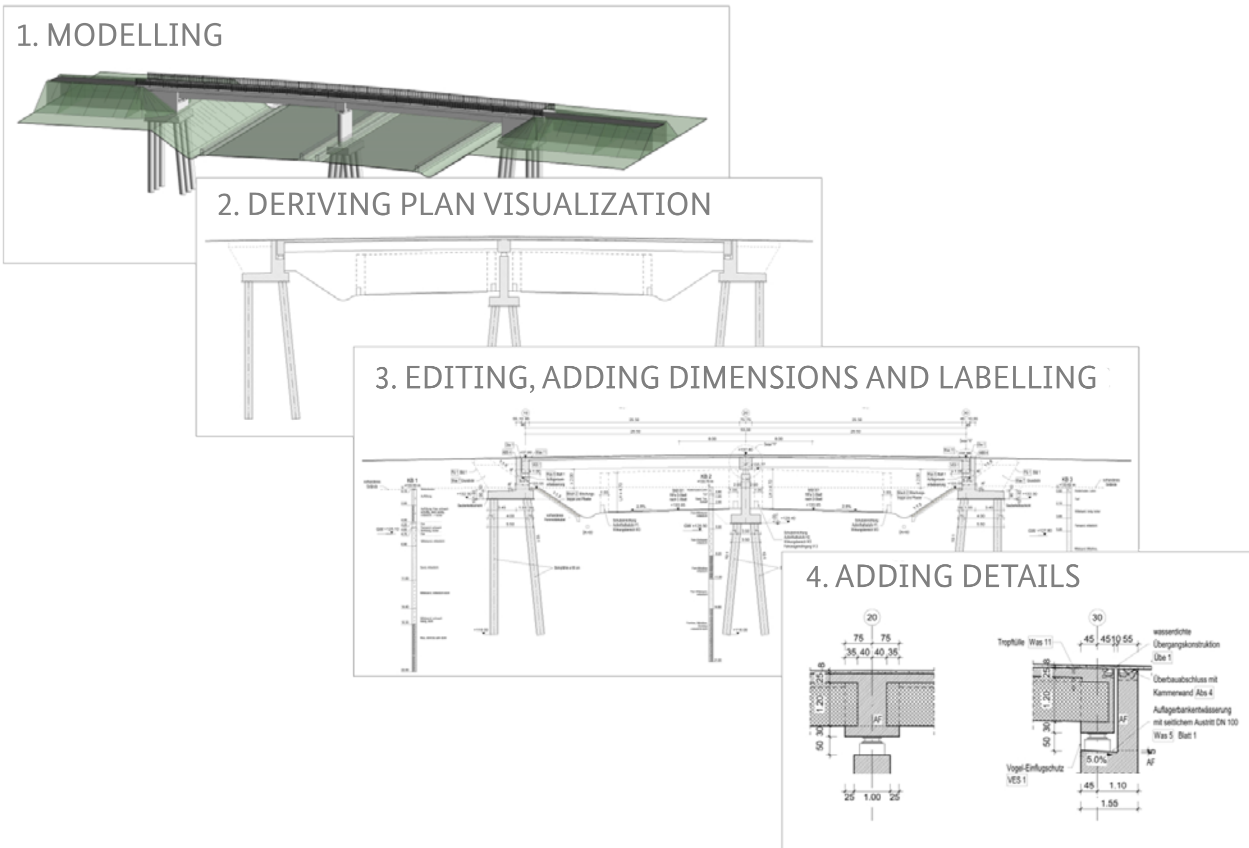


Figure 4: Steps of the model-based approach to generate design drafts (© Schüßler Plan) „Technical descriptions partially in German“

3.3 Obstacles created by existing conventions

The current visualization forms of RAB-ING described in section 2.1 create obstacles encountered with a model-based approach. These obstacles will be explained in detail in the following. Based on this explanation, alternative approaches that permit model-based plan derivation and display all relevant information at the same time will be developed in section 4.

The currently applicable conventions of RAB-ING are presented as two-dimensional designs in the context of creating design drafts (see section 2.2). The objective is to display the contents in a compact way with only few plan drawings. One example for this is a combined view of superstructures and substructures in the location plan. A geometrically idealized visualization of the engineering structure with as few plans as possible cannot be transferred to model-based planning in the BIM context (cf. section 3.1). Deriving plans from the model produces other geometrically exact visualizations and requires deviating conventions. This means that the following visualizations, in particular, cannot simply be derived in conformity with the guidelines:

- Longitudinal sections for skew bridges when visualizing abutments and piers with a section at a right angle to the substructure axis in combination with a section of the superstructure along the axis of the structure or the gradient

- Ground plans showing one half of the bridge with a top view of the superstructure combined with the top view of the other half's substructures with removed or open superstructure and abutments without backfilling

- Cross section of the earth body at the end of the wing wall in combination with the idealized view of the abutment

- Cross section of the superstructure in front of the abutment in combination with the idealized view of the abutment

- Cross section of the superstructure in combination with the idealized view of the piers

In general, the combined visualization forms (cp. indents 1 and 2) cannot be joined in a joint visualization. This would always require an overlay of several 2D visualizations derived from the model. An overlay is not consistent with the model and the labels/dimensions can usually not be added in the combined visualization.

Furthermore, an idealized visualization of a section through the superstructure/earth body with an elevation of the substructures (cf. indents 3 to 5) cannot simply be implemented in accordance with the currently applicable conventions. For this, it is not only necessary to overlay several elevations, but also to create an idealized representation of the edges of the structure without a three-dimensional visualization (see Figure 3). From a technical point of view, this is not possible for gradients that are usually sloping or rounded or for curved structure axes (cf. section 3.1). Objects within the section are represented in their exact geometry (see Figure 2).

4. Recommendations for deriving plans for engineering structures

The technical parameters of a model-based approach presented in section 3 as well as obstacles occurring due to the current forms of visualization render it necessary to define recommendations for generating design drafts for engineering structures derived from models.

4.1 Fundamental considerations to complement existing conventions

In general, based on the broad context presented here, it can be stated that the existing geometrically idealized visualization with as few plans as possible is not expedient when using a model-based approach in the BIM context (cf. section 3.3). As a consequence, more visualizations (among others, ground plans and sections) are generated overall. These can simply be derived from the model, since the structure was designed to be entirely three-dimensional from the start. An overlay or combination of multiple derived drawings in the same plan should be avoided since these can be conflicting or may not be understandable. Also note that when plans are derived from the model, the exact geometry is visualized. Therefore, idealized visualizations, which are the basis for the current visualization forms, cannot readily be created. When sections are made, the section depth should be as low as possible to derive clear visualizations.

As a three-dimensional model is generated, new visualization forms can be derived, which would be difficult or impossible to generate with a traditional two-dimensional design. In particular, 3D views of the structure can be generated directly from the model as perspective views or orthographic projections. This way, 3D views (see Figure 5) can be generated with or without making sections of the structure.

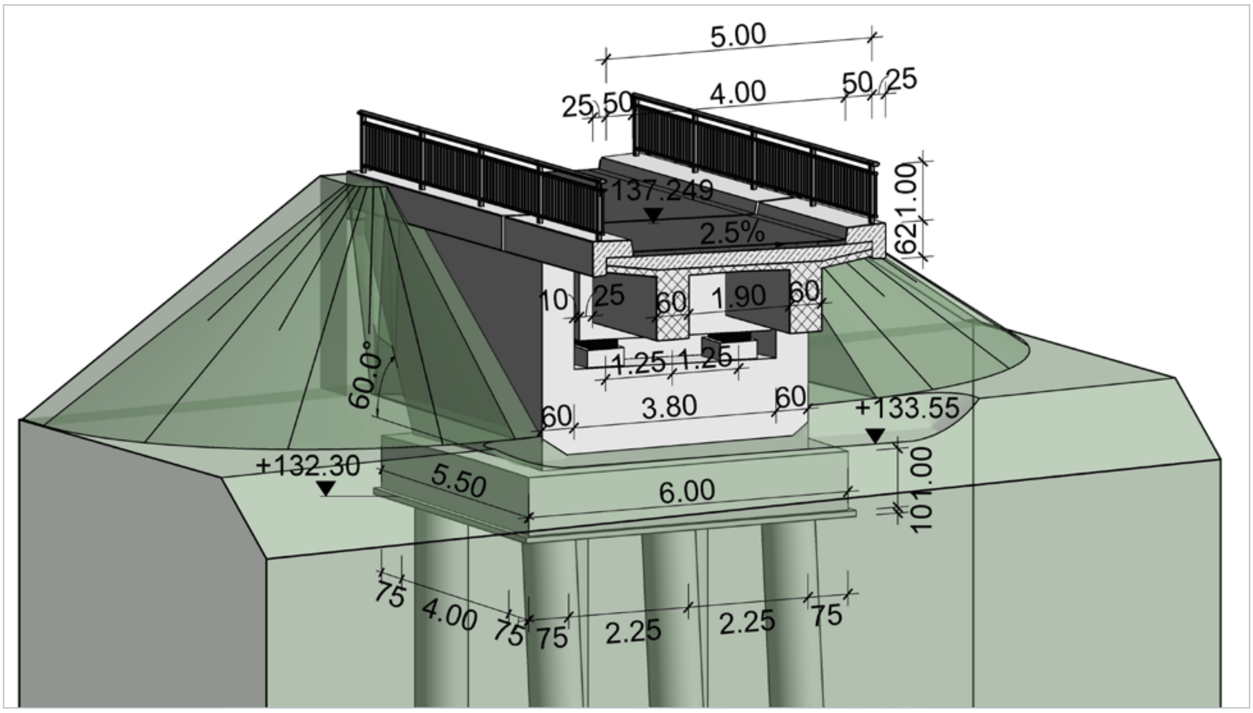


Figure 5: 3D view with orthogonal section to structure axis (© Schüßler Plan)

The models can also be used to generate three-dimensional exploded-view drawings, in which the individual components of the structure are presented as if the structure had been subject to an explosion, meaning the components are shown with spatial separation. The 3D views generated in the project are supplemental visualizations that are usually not subject to dimensioning. They give a better understanding of the structure.

For the 3D view presented in a structural plan, the line of sight has to be integrated in the ground plan. An example can be found in the plans of model example 6-2-1 (cf. section 5), derived from the framework document.

In addition to the derived plans, the generated models of the structure have to be considered deliverables as well. These are referred to as civil engineering specialist models. The specialist models that correspond to the plans, have to be named in a legend on the plans. The same applies to the project origins, which are the basis for the models (Note: The specialist models are generated in relative coordinates. Therefore, the project origin is of particular interest to transfer them to global coordinates). More detailed explanations on the model-based implementation of construction projects by means of specialist models can be found in the 'Definition of specialist models' framework document.

4.2 Visualization forms

The following visualizations of design drafts for engineering structures for the functional and technical description are considered to be useful for model-based plan derivation:

1. Overview:

   - 3D view of the entire structure, including the surrounding terrain
   - Unrolled longitudinal section in the structure's axis or gradient
   - Ground plan of the entire bridge with top view of the superstructure, visualization of the hidden substructures and the surrounding terrain

2. Abutment:

   - For skew bridges, a longitudinal section of the abutment, including foundations with section at a right angle to the substructure axis or abutment wall
   - Top view of the abutment with surrounding terrain without visualization of the superstructure
   - Elevation of the abutment with surrounding terrain, without visualization of the superstructure (interaction between superstructure and substructure in a separate cross section)
   - Composite profile of the abutment: Cross section of the superstructure at a right angle to the structure's axis with a section that is directly tangential to the outer edge of the abutment wall; without visualization of the surrounding terrain (interaction between substructure and the terrain in separate view)
   - Rear elevation of the abutment with surrounding terrain, without visualization of the hidden superstructure
   - Longitudinal view of the wing walls with surrounding terrain
   - Supplemental 3D view with visualization of the abutment; 3D section of the superstructure of the abutment; usually without a visualization of the surrounding terrain

3. **Piers:**
   - Top view of the piers with surrounding terrain, without visualization of the superstructure
   - Section view of the piers with surrounding terrain, without visualization of the superstructure (interaction between superstructure and substructure in separate cross section)
   - Composite profile of the piers: Cross section of the superstructure at a right angle to the structure's axis with a section that is tangential to the pier edge; without visualization of the surrounding terrain (interaction between substructure and the terrain in separate view)
   - Longitudinal view of the pier with surrounding terrain
   - Supplemental 3D view with visualization of the abutment; 3D section of the superstructure of the abutment; usually without visualization of the surrounding terrain
4. **Standard cross section**
   - Existing conventions for visualization remain unaffected
5. **Structural details**
   - Visualization of structural details, usually derivation of superordinate component geometry from the model and retroactive expansion of detailed elements in the derived 2D visualization, in isolated cases purely 2D visualizations

The recommendations described above will be illustrated in the following figures. Figure 6 shows the visualization of an abutment elevation by way of example in accordance with the existing conventions of RAB-ING. Figure 7 shows the recommendation for the visualization of contents when working with the model-based approach. It is intended to show the view of the abutment with surrounding terrain without the superstructure for a clear visualization (for a visualization with superstructure, cf. Figure 2). The interaction between the superstructure and the substructure is depicted in a separate visualization as a composite profile of the abutment superstructure.

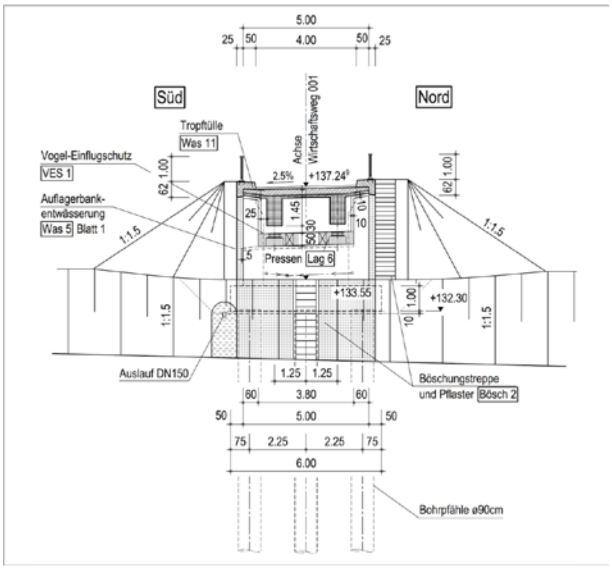


Figure 6: Abutment elevation in accordance with existing convention (© Schüßler Plan) „Technical descriptions partially in German“

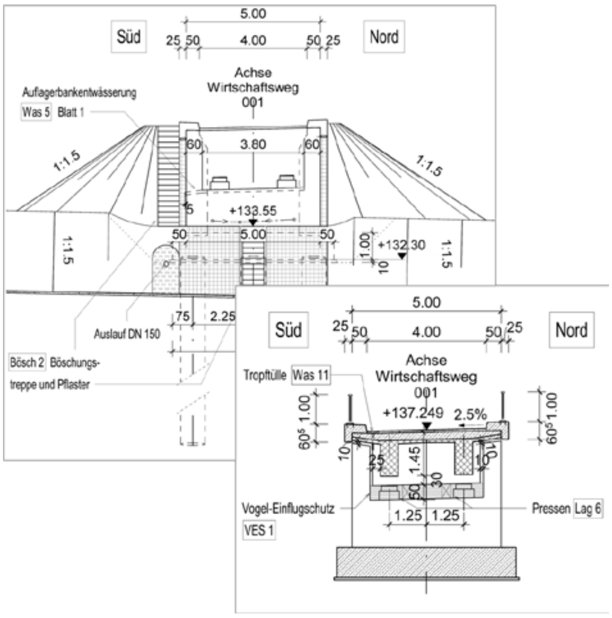


Figure 7: Recommendation on the abutment visualization (broken down into the substructure elevation and composite profile of abutment superstructure) (© Schüßler Plan) „Technical descriptions partially in German“

4.3 Sheet composition

Due to the higher number of visualizations, it makes sense to adapt the sheet composition. Based on the object-oriented approach in modelling, the composition is component-based, as is the case when positioning visualizations in the plan layout. The following layout is considered useful:

Table 2: Sheet composition recommendations for model-based plan derivation

Plan	**Description**
Plan layout 01 – overview 3D view Bridge Longitudinal section Unfolded view of structure axis or gradient Ground plan Top view of superstructure Legend Title block	▪ 3D view of the entire structure with surrounding terrain; it gives a better understanding of the structure ▪ Position the longitudinal section below the visualization ▪ Position the ground plan with only a top view of the superstructure at the same scale below the longitudinal section
Plan layout 02 – abutment Cross section Composite profile of superstructure on abutment Cross section Abutment elevation Cross section Rear elevation of abutment 3D composite profile Abutment Longitudinal section Elevation of wing walls Ground plan Top view of abutment Longitudinal section Elevation of wing walls Details Legend Title block	▪ Position abutment elevation in the top centre ▪ Top view of abutment at the same scale below the view; aligned by the structure axis ▪ Composite profile and rear elevation of abutment in the same scale next to view; vertically aligned ▪ Views of wing walls next to top view of abutment ▪ Position supplemental 3D view and details of abutment in free spaces
Plan layout 03 – piers Cross section Composite profile of superstructure on pier Cross section Elevation of piers Standard cross section 3D view Piers Longitudinal section Elevation of piers Ground plan Top view of piers Details Legend Title block	▪ Position piers elevation in the top centre ▪ Top view of piers at the same scale (or poss. larger scale) below the view; aligned by the structure axis ▪ Composite profile of abutment at the same scale next to view; vertically aligned ▪ Longitudinal view next to top view of piers ▪ Position standard cross section, supplemental 3D view and details of piers in free spaces

The number of plans and the individual composition can vary depending on project size and type. The individual visualizations have to be positioned in the layouts so that the corresponding axes of the structure are congruent, either superimposed or parallel.

The plan contents – as described in Part 4, section 1 of the RAB-ING – of ground plans, longitudinal and cross sections to be visualized as well as the scales on which they are based, remain unaffected by the above-mentioned recommendations. Supplemental 3D views are not at a specific scale.

4.4 Modelling scope and plan contents

Here, the objects to be modelled and those generated automatically from the model when plans are derived and/or the objects that are added manually in the 2D visualizations. Figure 8 shows a sample longitudinal section from model example 6-2-1. The objects derived from the model are shown in colour.

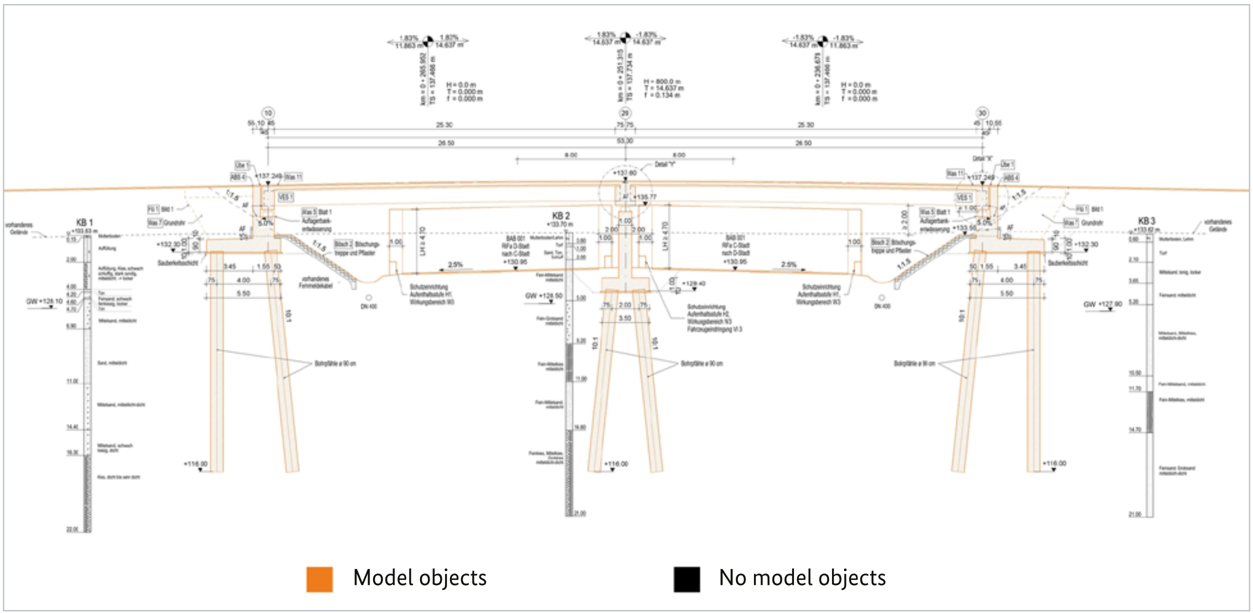


Figure 8: Comparison of the objects derived from the model and added manually in a sample plan visualization (© Schüßler Plan) „Technical descriptions partially in German"

In general, all bridge components (superstructure, substructure, foundations, caps, railing, etc.) must be modelled on the basis of the alignment defined by the transport planner. It is also necessary to integrate a digital terrain model and to model slope bodies and backfills. All model objects have to be classified unambiguously. Modelling of structural details or elements such as drainage systems or expansion joints is usually optional. Therefore, these can also be added later in the derived plans.

Table 3 contains recommendations for objects that could and should be modelled. The list is not exhaustive. Detailed or deviating definitions have to be made on a project-specific basis.

Table 3: Sample list of objects that are to be modelled and supplemented manually in derived plans

Mandatory modelling	**Optional modelling**
Superstructure (deck plate, longitudinal girder, cross girder, etc.)	Shorings
Substructure (piers, abutments, bearings, etc.)	Construction pits/excavated material
Foundations (foundations, piles, subbase, etc.)	Service stairs
Caps	Cable/line routes
Railings	Drainage systems
Surfaces	Expansion joints
Earthworks (side slopes, backfills, etc.)	Sealing
Protective walls	Bearings
Retaining walls	Lighting
Structure gauges/protection facilities	Signage
...	...

In the context of the change in methodology from the conventional plan drafting of two-dimensional structures to model-based plan derivation, please note that current CAD guidelines and layer conventions (cf. section 2.2) often cannot be used as part of BIM planning. While CAD data can usually be exported from the authoring software for the plans derived from the model, e.g. as DWG files, the entire model structure cannot readily be converted to layers. This has the effect that any layer conventions cannot be implemented one-to-one with the model-based approach and therefore have to be adapted. Furthermore, BIM planning makes layer conventions obsolete, because the model is classified and structured via the semantics. Standards for this have to be defined accordingly in the project.

5. Model example

To illustrate the recommendations presented in section 4 for deriving plans for the construction of new bridges, we will model the model example 6-2-1 ‘Overpass structures – farm tracks’ from RAB-ING and, based on this, derive plans from the model in this framework document.

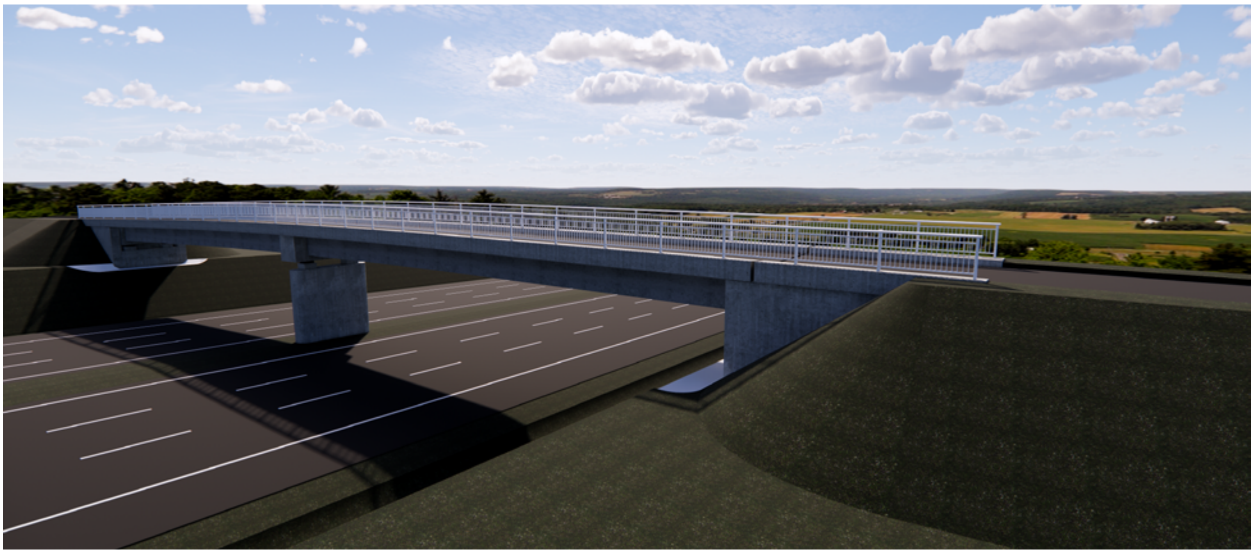


Figure 9: Visualization of model example 6-2-1 ‘Overpass structures – farm tracks’ (© Schüßler Plan)

The design of the structure is described from a functional and a technical perspective in three plan layouts. The chosen visualizations as well as the sheet composition are based on the recommendations made in sections 4.2 and 4.3:

1. Plan 01 – Layout plan
   - 3D view of the entire bridge
   - Longitudinal section A-A in the structure axis
   - Ground plan – Top view of superstructure
2. Plan 02 – Abutment (applies for both abutments, are identical)
   - Cross section B-B: Abutment elevation
   - Cross section C-C: Composite profile at outer edge of abutment
   - Cross section D-D: Rear elevation of abutment
   - Longitudinal section E-E: Elevation of wing wall (applies for both wing walls, are identical)
   - Ground plan – Top view of abutment
   - 3D view of abutment with section of superstructure orthogonal to the structure axis
   - Detail “X”: End supports

3. **Plan 03 – Piers and standard cross section**
   - Standard cross section
   - Cross section F-F: Elevation of piers
   - Cross section G-G: Composite profile at outer edge of piers
   - Longitudinal section H-H: Elevation of piers
   - Ground plan – Top view of piers
   - 3D view of piers with sections of the superstructure orthogonal to the structure axis
   - Detail “Y”: Intermediate supports
   - Detail “Z”: Prefabricated joint

The following Figure 10 presents ‘Plan 02 – Abutment’ by way of example.

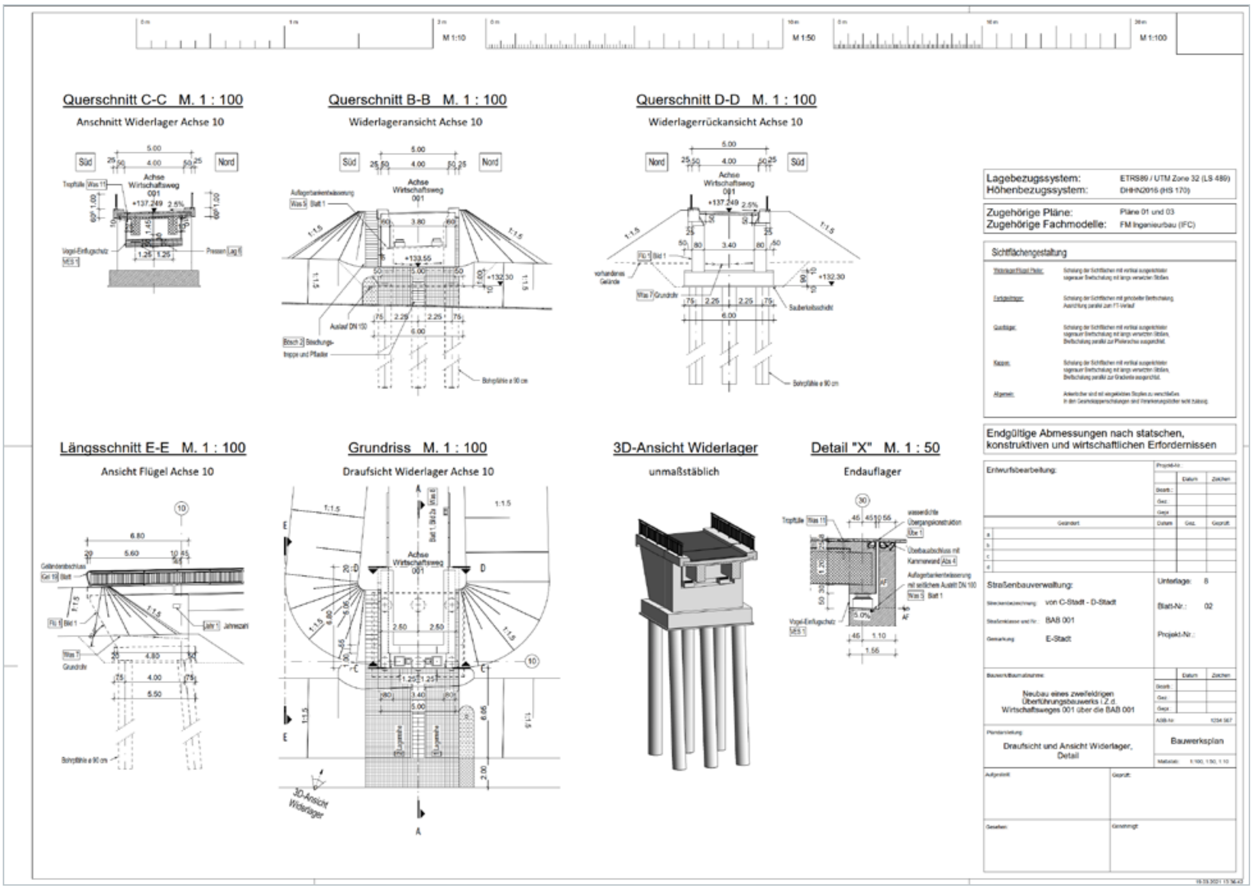


Figure 10: Derived plan visualizing the abutments of the model example 6-2-1 (© Schüßler Plan) „Technical descriptions partially in German“

The results of the implementation (civil engineering specialist model as well as derived design plans) are included in the Annex of this framework document.

6. Summary

This framework document presents the existing requirements for the preparation of design plans for engineering structures in accordance with RAB-ING as well as obstacles when working with the model-based approach. Based on this, recommendations are established for deriving plans for the construction of new bridges. The most important aspects of this document are summarized as follows:

- A geometrically idealized visualization of the engineering structure in accordance with existing conventions in as few plans as possible cannot be transferred to model-based planning in the BIM context.
- Deriving plans from the model results in geometrically exact visualizations and leads to deviating conventions.
- Plans are derived on the basis of quality-assured, geometrically consistent models. The geometry of the models must be confirmed by the contracting authority in the course of the design process, before plans are derived.
- With the model-based approach, ground plans and sections can be derived relatively easily from the model, since the structure was designed entirely in three dimensions from the start. Therefore, in total, more visualizations should be generated for the functional and technical description of the structure.
- An overlay or combination of multiple derived drawings in the same plan should be avoided since these can be conflicting or may not be understandable.
- The visualization of the geometry of ground plans and sections derived from the model has to be dimensioned, labelled and edited. Structural plans have to be prepared based on geometrically consistent models after the modelling process has been concluded.
- It is not strictly necessary to model all objects. Detailed elements, in particular, can be added manually in the derived 2D visualizations.
- 3D views serve to better understand the structure and are integrated in the plans as supplementary visualizations.
- In addition to the derived plans, the specialist models of the engineering structure are also deliverables of the design draft. Corresponding models and project origins that these are based on have to be shown in the plans.
- Any existing layer conventions cannot be transferred to the model-based approach and have to be discarded. They are replaced with an object classification of the model.

The recommendations are implemented by way of example based on the model example 6-2-1 'Overpass structures – farm tracks'. The outcome of this framework document is a fully-fledged plan derivation as alternative documentation of the design based on RAB-ING. The visualization is considered equivalent in terms of the information depth of the existing documentation formats and, when combined with the building model, more advanced. The recommendations represent the current state of the art and serve all parties involved in the project as a guideline for the preparation of design plans of engineering structures when working with a model-based approach.

The framework document for the documentation of design drafts for engineering structures has to be agreed by contract in addition to RAB-ING as documentation requirements when working with BIM projects. Here, it has to be clarified that requirements of RAB-ING, which do not affect the plan documentation, remain unaffected by this agreement.

7. Outlook

The listed recommendations and the revision of model example 6-2-1 constitute a proposal for the expansion of RAB-ING for the construction of new bridges in the context of a model-based approach for performance level 1 (LN 1). However, these can only mark a first step to expanding the conventions of RAB-ING in their entirety. In future, the recommendations are to be expanded to cover repair and strengthening works as well as the construction of replacement structures for bridges and other structure types, such as tunnels and protection walls, including the development of further model examples beyond the scope of this framework document.

Currently, plans form the main basis for design documentation. The building information models produced are only used as a secondary source for documentation purposes. Therefore, model-based plan derivation can only constitute a first step towards a comprehensive digital handover and release of design drafts, where the documents form the primary basis for planning documentation. Therefore, in the future, efforts should be geared to working largely without plan derivation or not using it at all.

8. References

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Annex

The following annexes are attached to this framework document:

I. Civil engineering specialist model of model example 6-2-1 Overpass structures – farm tracks' [IFC]

II. Structural plans derived from building information model of model example 6-2-1 '"Overpass structures – farm tracks' [PDF]

- Plan 01: Layout plan (3D view, longitudinal section, ground plan)
- Plan 02: Abutment (3D view, elevations, cross sections, details)
- Plan 03: Piers (standard cross section, 3D view, elevations, cross sections, details)

The Annex is only available as download on the BMVI website, click 'Masterplan BIM - Bundesfernstraßen'.

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