Güteschutzverband Betonschalungen

GSV Guidelines
BIM Formwork Technologies
Discipline Model
(In situ concrete construction)

Data exchange model for the use of BIM methods in formwork planning and design

Information Delivery Manual IDM

Contents

1 Preface

BIM (Building Information Modeling) is a new method of working in construction project organisations. It is based on networked cooperative planning, design, execution and management processes on construction projects or structures through the integration of data and information in a centralised model. The objective is to generate a basis for construction that will be adequate for all phases and project participants and to ensure that all data and information are prepared without the risk of mistakes or discrepancies and can be exchanged.

Highly developed formwork and scaffolding systems (load-bearing, working, safety and facade scaffolds) are available for the execution of construction works and components. These systems must be adequately designed and efficiently used if a construction project is to be completed on time and a success in terms of quality and cost effectiveness. It must be mentioned in this context that formwork and scaffold manufacturers have developed and used software systems for formwork design over many years and have made them available to users. This creates a very good foundation for their integration into the BIM method. On the initiative of companies in the construction industry, the Güteschutzverband Betonschalungen Europa e.V. as the representative of formwork manufacturers and users, the Deutscher Beton- und Bautechnik-Verein E.V., software manufacturers and the Institut für Baubetrieb at the Technical University of Darmstadt (TU Darmstadt) as the representative of research and education establishments, projects to achieve integration were undertaken and implemented within buildingSMART e.V. as part of the activities of the BIM Formwork Technologies Discipline Model (In situ concrete construction) Working Committee.[1]

The following *BIM Formwork Technologies Discipline Model (In situ concrete construction)*, a data exchange model for the use of BIM methods in formwork planning and design, was developed for the purpose of achieving the transparent transfer of information relating to formwork for in situ concrete construction between the project participants in the various phases of a construction project. The model complies with the requirements for IDM (Information Delivery Manual) status in accordance with buildingSMART standards. According to buildingSMART, the requirements for data exchange must be generally specified in the IDM descriptions and define the fundamentals of the scope and specifications of the information that must be made available to a specific role (user) at a specific time or for a specific work process in a BIM project.[2] The discipline model shown below takes into account the one-off nature of manufacturing in the construction industry and the fact that the present division of work in the organisation of construction projects means the formwork supplier and the formwork designer are often key participants in a construction project.

2 Basic principles

The way the BIM Formwork Technologies Discipline Model (In situ concrete construction) works is based on the flow of data and information complying with BIM standards in a structure of five levels of development LOD^{FW} 100 to LOD^{FW} 450 (Level of Development Formwork Technologies LOD^{FW}), which must be contractually agreed to suit the individual requirements of the construction project. Intermediate levels of development, such as LOD^{FW} 250, can be individually defined. These intermediate levels arise when elements or parts of them are used in the levels of development above or below.

The model complies with the requirements for IDM status as set out in the buildingSMART standards in that the scope and specifications of the data and information to be exchanged between specific project participants at specific periods of time or for specific processes are defined in principle.

As a result, the following inputs (among others) for the design and construction of construction projects are supplied:

a) Definition of the processes and technologies used for the construction of the load-bearing structure,
b) Data and information for the cost estimate and pricing,
c) Data and information for the work planning for the production processes,

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[2] buildingSMART e.V.

d) Design documentation and visualisations for the construction sites,
e) Data and information for process control on the construction site,
f) Data and information for the issue of health and safety at work.

3 Level of Development Formwork Technologies LOD^{FW}

3.1 Process related

The design of formwork in the BIM method on the basis of the Level of Development Formwork Technologies LOD^{FW} can be expressed generally in the traditional process structure of a construction company as shown in Fig. 1. As a general rule, the formwork design becomes more detailed as the project progresses. The data and information input for working on the formwork design in the individual processes and process phases should be agreed for each project.

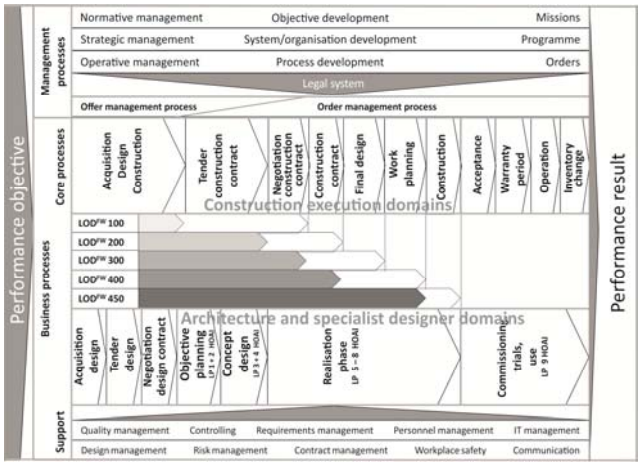

Figure 1: Process structure of a construction company arranged in terms of LOD^{FW}

3.2 Content of LOD^{FW} 100

In level of development 100, the project, as far as the process structure of the construction company is concerned, is in the phase of project acquisition for the design and construction or may be in the bidding phase. It is assumed that in LOD^{FW} 100 the created model is based on the overall dimensions of components, without any deeper assignment of properties. As the design progresses, data and information such as the structure category, its function, the relevant boundary conditions, characteristic geometrical data and approximate form of the structure are added. In the case of formwork planning and design, this information is very useful for generating formwork design guidance values for assessing general feasibility and obtaining reference data from already completed construction projects. The information does not have to relate directly to the construction project being designed. The data structure can contain documents such as text, images or drawings. An overview of the output from the model and the input into the model for this level of development is shown in Figure 2.

Output from the model ("Design input")	**Input into the model** ("Design output")
• Structure category • Structure function • Boundary conditions • Characteristic geometric data (e.g. bridge length, tower height) • Approximate form of the structure	• Formwork design guidance values (feasibility) • Reference data (e.g. costs, construction types etc. from comparable projects)

Figure 2: Data and information in LOD^{FW} 100

3.4 Content of LOD^{FW} 200

Level of development 200 represents the bidding phase in the process structure of the construction company. The model created here is used by the construction company mainly for obtaining a defined price for the project. However, the information in the model consists of only basic execution-related parameters during this phase. In comparison with LOD^{FW} 100, the model has been defined and the approximate construction sequence expanded. At this stage, the information relevant to the formwork design, e.g. the properties of fair-faced concrete, waterproof concrete or particular features such as thermally activated building components, is integrated into the model. For the formwork design, it may be that the project-related price and execution time guidance values can be output on the basis of the formwork categories and associated approximate technical specifications contained in this model. An overview of the output from the model and the input into the model for this level of development is shown in Figure 3.

Output from the model ("Design input")	**Input into the model** ("Design output")
• Building component properties – Dimensions – Position – Main properties (reinforced concrete, concrete strength class, …) – Special properties (waterproof concrete, thermal activation of building components, …) • Fair-faced concrete properties – Fair-faced concrete class – Project-specific agreements • Architectural perforations (windows, doors, …) – Dimensions – Position • Approximate construction sequence: Sequence of the areas of the works	• Guidance price [€/unit] formwork and scaffolding material related to the building component type • Guidance execution time values [h/m^2] • Formwork system category with approximate technical specification (universal formwork, standard formwork, special formwork)

Figure 3: Data and information in LOD^{FW} 200

3.5 Content of LOD^{FW} 300

Level of development 300 reflects the phase in the process structure of the construction company between the definition of what is to be built (construction contract) and the beginning of the final design. Process-related information such as the individual sections or parts of the structure and a production schedule are added to the contents of LOD^{FW} 200. For the formwork design, it may be that these project-related price and execution time guidance values can be optimised with respect to their quantities. The type of formwork system and the associated approximate technical specification are also added at this time. The optimisation is done on the basis of specific requirements, mainly derived from the construction programme, in an iterative process in a dialogue between the formwork designer and the work planner. An overview of the output from the model and the input into the model for this level of development is shown in Figure 4.

Output from the model ("Design input")	**Input into the model** ("Design output")
• Building component properties – Dimensions – Position – Main properties (reinforced concrete, concrete strength class, …) – Special properties (waterproof concrete, thermal activation of building components, …) • Fair-faced concrete properties – Fair-faced concrete class – Project-specific agreements • Architectural perforations (windows, doors, …) – Dimensions – Position • Component production parameters – Concreting stages – Construction and expansion joints – Fresh concrete properties • Construction programme using an approximate sequence, activity durations and assigned components	• Guidance price [€] for the formwork and scaffolding material based on the indicated material state (proportions of new and used material) • Guidance execution time values [h/m^2] • The type of formwork system with technical specification (e.g. frame or beam formwork) • Material quantities related to activity durations • Assignment of the formwork and scaffolding material (product groups) to their instances of use (structure geometry)

Figure 4: Data and information in LOD^{FW} 300

3.6 Content of LOD^{FW} 400

Level of development 400 represents the process structure of the construction company between the final design and the work planning. All the installed components and effects arising out of the states of the project during construction are added to the LOD^{FW} 300 model. A complete formwork utilisation plan can be drawn up based on the LOD^{FW} 400 model. The output of this formwork utilisation plan includes the further project-related price and execution time guidance values and detailed information about the formwork system (product information). The contract for the supply of the formwork should be finalised at the latest in this level of development. An overview of the output from the model and the input into the model for this level of development is shown in Figure 5.

Output from the model ("Design input")	**Input into the model** ("Design output")
• Building component properties – Dimensions – Position – Main properties (reinforced concrete, concrete strength class, …) – Special properties (waterproof concrete, thermal activation of building components, …) • Fair-faced concrete properties – Fair-faced concrete class – Project-specific agreements • Architectural perforations (windows, doors, …) – Dimensions – Position • Component production parameters – Concreting stages – Construction and expansion joints – Fresh concrete properties • Construction programme using the detailed construction sequence, scheduled deadlines, activity durations and assignment to components • Installed components – Position – Dimensions – Materials	• Quotation price [€] for formwork and scaffolding material based on material state (proportion of new and used material) • Guidance execution time values [h/m^2] • Actual product formwork system with technical specification • Material quantities related to activity durations • Assignment of the formwork and scaffolding material (in detail) to their instances of use (structure geometry)

Figure 5: Data and information in LOD^{FW} 400

3.7 Content of LOD^{FW} 450

Level of development 450 represents the process structure of the construction company in the period between work planning and construction. This is similar to level of development 400, but is based on the contract for supplying the formwork. The output is a detailed formwork utilisation plan in accordance with the contract, the content of which may include all geometric representations of the formwork and scaffolding structures as well as additional information such as assembly and operating manuals. An overview of the possible output from the model and the input into the model for this level of development can be seen in Figure 6.

Output from the model ("Design input")	**Input into the model** ("Design output")
• LOD^{FW} 400 referenced to the contract	Formwork design in accordance with the contract, e.g.: • Datasets and data transfer • Optimisation of the formwork solution • Assignment of individual formwork elements to the component (tracking) • Visualisation of the formwork utilisation – geometric model (geometric and technical data and information about the formwork and scaffolding elements) • Construction programme for the formwork utilisation including logistics (e.g. delivery and pick-up dates) • Additional information, e.g. assembly and operating manual • Components permanently installed with the formwork (e.g. plate anchors) • Permanent geometric features created in the concrete (e.g. anchor points, bearing pockets) • Components installed temporarily with the formwork (e.g. cones for climbing scaffold bracket attachment points, tie rods)

Figure 6: Data and information in LOD^{FW} 450

4 Implementation of the BIM discipline model

The use of the BIM Formwork Technologies Discipline Model (In situ concrete construction) presupposes that the input and output values are communicated in a defined parameter list, which forms the basis for a database-style implementation in the various IT systems. The list shown in Table 1 is a hierarchy of parameters identified and considered as relevant by the working committee and assigned to each level of development.

The parameter list was drawn up and intended to provide an example to be used as the basis for developing a prototypical parameter tool. It demonstrated that a robust form of data export and data transfer into different design software are possible.

Table 1: Parameter list (content following the completion of the design stage in each LOD^{FW})

Subdivision	From LOD^{FW}	Attribute
Formwork components	**100**	Formwork design guidance values
		Reference data
	200	Formwork system information
		Technical specification
	300	Material quantities
	EXAMPLE OF A CLIMBING BRACKET CONE	
	450	Description
		Article No.
		Number required
		Self-weight
		Position (x, y, z coordinates)
		Dimensions (e.g. length, width, height, …)
		Load capacity
		Extent of effect in x direction
		Extent of effect in y direction
		Extent of effect in z direction
Timing information	**200**	Guidance execution time values for formwork
		Construction sequence
	300	Activity durations
Price information	**200**	Price information for formwork (standardised)
		Price information for scaffolding (standardised)
Component of the structure	**200**	Description
		Dimensions (length, width, thickness/height)
		Position (x, y, z coordinates)
		Main properties
		Construction material
		Construction method
		Structure class
		Concrete strength class
		Exposure class
		Proportion of reinforcement (by volume)

Subdivision	From LOD^{FW}	Attribute
		Proportion of reinforcement (by area)
		Special properties
		Measurement accuracy class
		Tolerances
		Thermal activation of building components
		Waterproof concrete
	400	Self-weight concrete / reinforcement
		Other effects
	300	Concreting stage
		Position of construction joint (x, y, z coordinates)
		Position of expansion joint (x, y, z coordinates)
		Construction programme information
Recesses and voids	**200**	Position (x, y, z coordinates)
		Dimensions (length, width, height)
Installed components	**400**	Position (x, y, z coordinates)
		Dimensions (length, width, height)
		Material
Concreting parameters	**300**	Workability class
		Maximum horizontal pressure due to wet concrete
Fair-faced concrete	**200**	Fair-faced concrete class
		Texture class
		Permeability class
		Colour uniformity class
		Surface evenness class
		Construction and expansion joint class
		Formwork lining class
Utilisation	**450**	Delivery to site programme dates
		Pick-up from site programme dates
		Assembly and Operating Manual

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