How to Develop a BIM-Workflow for Landscape Architecture: A Practical Approach

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Abstract: Based on the example of planning an open space, the functionality of a BIM workflow was tested. Based on generated 3D models, significant steps in the BIM process such as planning, quantity surveying, collision testing and IFC export can be carried out. The foundation is the formulation of request profiles for the 3D modeling of the elements. Further uses in implementing BIM in landscape architecture are also discussed.

Keywords: Building Information Modeling (BIM), landscape design, BIM workflow, BIM elements

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Introduction

The use of BIM (Building Information Modeling) in Germany is being driven by initiatives of the Federal Ministry for Transport and Building. Starting in 2020 it will be obligatory to use BIM for the development of public projects having a budget of 5 million Euros or more. There are high hopes for increased productivity of the entire chain of planning, construction and facility management, especially through the optimized coordination process among participants. While the use of BIM in building and infrastructure planning is already established in both the public and private sectors, it is just beginning to be used in landscape architecture.

This also holds true on the international level. Mike Shilton (2018) gives an overview of the UK´s strategy for introducing BIM, at which 3 levels of BIM are defined. He points out that IFC standards for landscape elements still need to be defined. The Norwegian BIM for Landscape initiative demonstrates a first approach. In order to enable a proper landscape modeling process they have created a set of definitions, parameters and proposed code lists to combine efforts towards a unified landscape object standard (HALLGEIR et al. 2018).

Increasingly, landscape architects are also expected to use 3D BIM models. This is currently the case in Germany, especially in planning open spaces for real estate projects where BIM is being used by the other trades.

The workflow is such that the technical aspects are all consolidated in a 3D BIM model known as the coordination model. This takes place via the interface for model-based data exchange, IFC (Industry Foundation Classes). This builds upon 3D object models exclusively. This means that 2D CAD drawings cannot be transferred into a BIM coordination model.

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The creation of a 3D BIM model must be related to a clearly recognizable value. This is the case, for example, with visualizations that require little additional effort. It is a real advantage when the developed model can be used throughout the complete life cycle

Component and Software Requirements

The goal is to formulate the criteria for 3D modeling of landscape architectural components, to use these to create a 3D BIM model, and to assess the realizability of a BIM workflow. The 3D model should serve the derivation of the required data for tendering and cost calculation. Clash detection is used to check the quality and the 3D place model is selected through IFC.

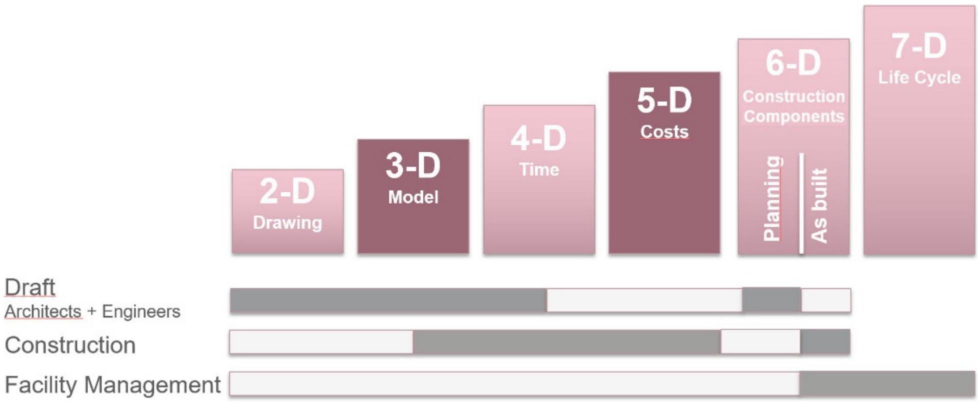

Fig. 1: BIM 2D to 7D – Considered in article: 3D – model and 5D – costs

A 2D draft and construction drawing serve as the basis. The following model elements are required for the sample area:

- Paved areas and edging
- Drainage systems and pipes
- Walls, steps and ramps
- Design elements – plantings and outdoor furniture

In creating elements, technical requirements need to be met. These are based on technical guidelines, the state of the art and possibly other policies. Additionally, rules for correct and efficient 3D Modeling are formulated. The resulting request profiles are then summarized as flow charts for all elements.

Figure 2 shows an example procedure for paved surfaces. The type of use and the resulting requirements specification dictate the means of construction (in Germany regulated by *FLL-ZTV-Wegebau).* Additionally, the surface material and layout pattern need to be selected. After deciding whether a frost protection layer is necessary, the bearing course and leveling layer are defined.

From this arise the requirements for the software tools in relationship to the modeling of paved areas, as well as the generation of information for the tendering and cost estimate. Flexible modeling tools that can depict complex geometric forms such as irregular polygons or areas with curves are essential. It must also be possible to assign points of definition for the borders as well as differing heights in the interior of the area (MAßLING 2018).

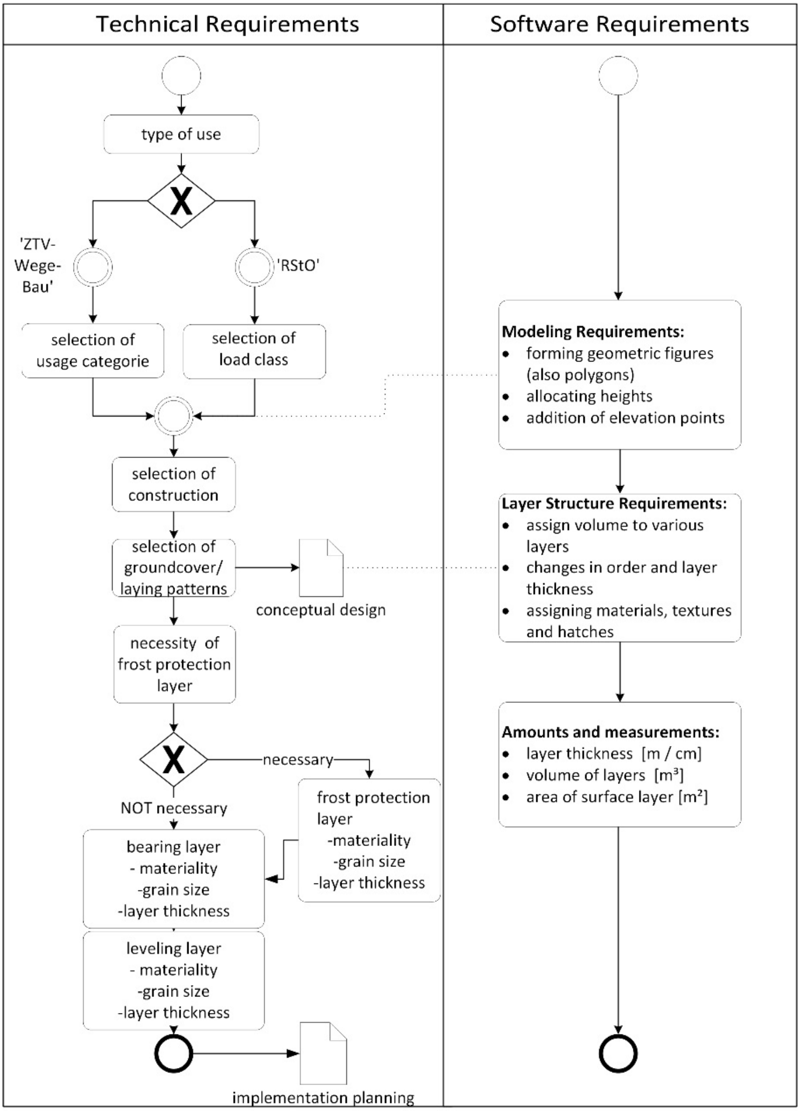

Fig. 2: Requirements for modeling paved areas using BIM

As a rule, paths and open spaces consist of a number of layers. The modulated volumes must therefore include the following information:

- Layer structure, thickness and material of individual layers
- Textures for the surface material (3D visualization/rendering)
- Hatches for a 2D sectional image

The following criteria are important for the cost estimation:

- Area of surface layer
- Thickness of layers
- Volume of individual layers

The next step is the creation of a 3D BIM area model. Fundamentally, a BIM planning software should function as follows:

- Generate components (model elements) as three dimensional parametric objects, link them with alphanumeric information, and categorize them into structures (site surfaces, or in building construction as stories)
- Derive plans and component lists for determining quantities from the model
- Provide interfaces for model-based data exchange

These general requirements are currently met using BIM CAD tools that have already been established in building construction. For processing, Autodesk Revit was chosen. Revit provides building components such as walls, ceilings, stairs, etc. in building construction

The following step tests how specifications can be used in 3D modeling with the help of Revit.

3D Open Space Model

Based on the specifications, all appropriate tools for the elements are compared. The tool that appears to be most appropriate is then used for the modeling. This is the same as when processing in areas that until now have no IFC objects.

The IFC object IfcSlab employed in building construction for ceilings (for example) which have a variety of heights and are constructed in layers can also be used for paved surfaces. Components such as edging stones, supporting walls, etc., have had no IFC classification until now. However, all elements can essentially be processed as special components (IfcProxy) using free defining custom Psets. This is comparable to applying block-based 2D libraries in conventional CAD.

The required level of detail in the various planning phases is of significance in creating elements and using them in the BIM process. These are not elements from the IFC definition of objects but rather are defined as EIR (Employer Information Requirement) which come from the client. The detailing mostly follows the American example using five levels of detail (LOD 100 – Preliminary Design to LOD 500 – Facility Management). With this, the exactness of the geometry (LOG) as well as the information (LOI) are defined. Currently, this appears too differentiated to put into practice so elements are developed in two LOD steps (LOD Design, LOD detailed design phase with construction drawings). This is also frequently the case in building construction. The level of detail in 3D models is often on the scale of 1:50 while details are presented in 2D. (BUNDESARCHITEKTENKAMMER E. V. 2017).

Table 1: Evaluation of modeling tools in Revit for paved areas

Requirements	**Modeling tool**		
	Terrain	**Cover**	**Ceilings and Floors**
Modeling perimeters/surfaces			
Creating complex contours	✓	✓	✓
Assigning heights	✓	×	✓
Additional reference points	✓	×	✓
Modeling layer structure			
Assigning volume of multiple layers	×	✓	✓
Changing order and thickness	×	✓	✓
Assigning materials, textures, and hatches	×	✓	✓
Demands on amounts and mass			
Layer thickness	×	✓	✓
Volume of layers	×	✓	✓
Area of surface layer	×	✓	✓
✓ – requirement fulfilled × – requirement not fulfilled			

Figure 3 shows the results of the 3D model of the open space. It was possible to create all the required elements. The model is useful for visualization and shade analysis. 2D interfaces and views can be derived from the 3D model and are automatically generated when changes occur.

Fig. 3: 3D model of an open space and the resulting plant maps (site plan, cross-sections)

Using currently available BIM software for projects in landscape architecture requires quite a bit of handwork. This is the case, for example, in building up an elements library. In the example project, parametric components (called families in Revit) were generated for a supporting wall. This means that all the retaining wall units and corner elements with individual dimensions can easily be derived from a prototype.

Fig. 4:
Wall sections as user-modified parametric components (LOD planning)

3D BIM models make collision checks possible. With the help of a model checker, the consistency of one's own plan can be checked and subsequently used to coordinate with the work of the other planners and architects. In the present example, intersections of the wall unit volumes and the plaster layer are detected that can, through modeling, subsequently eliminate excavation. The Autodesk tool Naviswork Manage is used here. Thus, use of additional specialized software such as Solibri is not necessary.

Finally, the 3D model of the open space is exported from the Revit data format into the software independent IFC format. It is opened in the IFC viewer and checked (KIT 2018). All model elements as well as their geometrics and attached information are available completely. This makes the 3D model appropriate for use as part of a BIM cooperation model and for use in coordinating with the work of the other planners and architects.

5D – Tendering and Cost Estimates

One goal of BIM is the correct calculation of quantities to be used in tender documents. Required masses can be called up from the 3D model by request and filtering, and then listed. A manual evaluation is thus deemed superfluous. The generated list can be read as Excel data, for example. Revit requires additional tools for the data transfer on the interface of software for tender, placing and account. These are available from a number of software suppliers. Alternatively, software for tender, placing and account makes possible the direct import from IFC models and the assigning of tender texts, visually supported by a 3D viewer.

An especially convenient solution is the DBD-BIM app by Dr. Schiller and Partner. This app was tested during the example project. It is an online solution integrated in CAD software. It offers the opportunity to match the components' tender texts and unit prices. This is based on a classification and description system. With it, the BIM data model contents are compatible with tender texts and can be filled in with data of IFC standards (DIN SPEC 91400, SCHILLER & FASCHINBAUER 2016).

As long as the components used are consistent with IFC, cost calculations and specs run for the most part automatically and smoothly with help of the DBD BIM app. In the case of paves surfaces, plants and other specific modeling objects of landscape architecture for which no

IFC yet exists this automatization is not possible. This means the 3D elements must be selected and then assigned by hand to the appropriate elements of the DBD BIM structure.

For efficient calculation of quantities, the meaning of explicit IFC objects as well as “Real” 3D modeling becomes very clear. Problems arise when, for example, borders such as curbstones are modeled with single stones that are counted by piece even though the required unit is “m”. Furthermore, it is desirable that future versions of DBD BIM app take into account overlapping dimensioning (as is the case for window openings in walls).

With the linking of tender texts, the capacity of the databank concept of BIM becomes clear. Principally, a great deal of additional information can be linked as desired. DBD BIM combines, for example, relevant technical norms and regulations, which then can be custom fit into the planning process. Also well worth considering would be having links to plant lists from nurseries and perennial suppliers.

Conclusion and Outlook

Through using a 3D BIM model for the chosen example open area, the already available elements of a BIM process can be illustrated. These include planning and element lists for calculating quantities from the model as well as the transfer of data via the IFC interface for the model-based data exchange. Scientifically supported practice-oriented pilot projects involving landscape architects would be expedient in building up know how.

The illustrated example can of course only present a small part of the possibilities of landscape architecture planning. Presently, no single software can cover everything. Branch specific CAD software has deficits in basic BIM functions; infrastructure software is not suitable for construction. Software for building construction has limited functions for terrains. Still, other fields also need to find solutions here. One example is road construction. Bridges are generated as special elements in building construction, and transferred via IFC to the civil engineering software and integrated into terrain and road construction planning. There are already interfaces where the integration of GIS is being tested as seen in the German *BIM-Infrastruktur-Pilotprojekt A99* (SCHALLER et al. 2017).

The linking of information as a significant feature of BIM has not been addressed in this paper. However, this is essential for the possible acquisition of the BIM model as the database for green space management. Exactly this BIM approach is relevant as high costs can occur in the operation phase of the open space. German producers of products for the green sector also see the necessity of a closer examination of BIM. The Landscape Institute UK’s available suggestions for Product Data Templates (PDT) based on a master template of the Chartered Institute of Building Services Engineers (CIBSE) offer such a link. The FLL (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau) in Germany is currently leading a discussion on PDTs for concrete elements and nursery products.

It is often not clear exactly which information the landscape architect is responsible for delivering in a project using BIM. For building construction and civil engineering complex process maps are developed (Who delivers what, to whom, to which depth?) which also serve as the framework for the formulation of EIR (Employer Information Requirement). On this basis, a prototype of a Reference Process BIM for Open Space was developed. This in turn could deliver the basis for a model EIR that would describe the BIM capacity while taking into consideration what is implementable from the landscape architect's perspective. Already in the relatively straightforward example presented, it is clear how important it is to formulate BIM applications accompanied by modeling instruction at the beginning of the project in ERP. Only so can one be sure that later on, the basis of the BIM models can be evaluated as say for quantity determination and linking of services and costs (5D) or the simulation of the building time schedule (4D)

The software-independent formulated requirements profiles for modeling specific elements for landscape architecture serve here in the selection of appropriate modeling tools as well as a guide for creating the area model. They can also help in the discussion with software producers about new or continuing developments of BIM tools.

Above all, they offer the basis for the development of BIM standards for landscape architectural elements. IDMs (Information Delivery Manuals) are being developed for the further development of IFC standards. This method of defining the requirements for data exchange in specific BIM applications is presented in DIN EN ISO 29481. In the expert group *BIM in Landscape Architecture* in the German chapter of buildingSmart, IDM Plants as well as IDM Paved Surfaces are discussed. To advance the definition and standardization of BIM processes in the area of landscape architecture national and international coordinating processes are essential. A promising start is the Activity Proposal for buildingSMART International, named 'IFC for Site, Landscape, and Urban Planning' by Jeffrey Ouellette, buildingSmart International.

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