

# BIM implementation in bridge modeling

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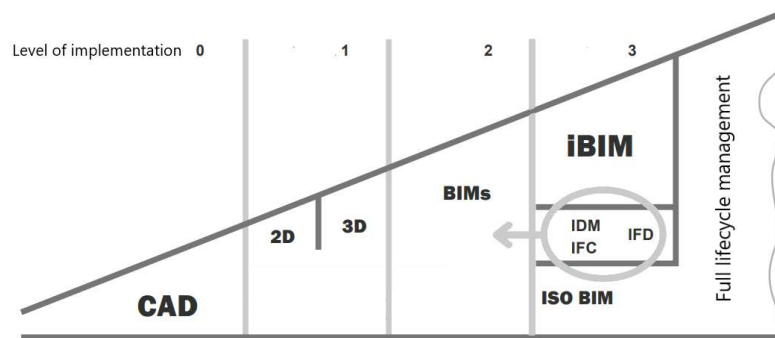
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**Abstract:** BIM is digitalizing construction sector and making it much more efficient. The base point is a 3D model which contains a lot of information. In this paper, firstly, the BIM approach will be briefly explained. After that the focus will on the creating process of designing a BIM bridge model that was designed and drawn in AutoCAD as part of author's Master study. BIM software used were Allplan and Allplan Bridge. The software workflow is explained by itself and on the example of designed composite bridge. The two design methods are compared in terms of efficiency and ways of usage.

**Keywords:** BIM, Allplan Bridge, modeling, bridge

## 1. Introduction

BIM (abbr. *Building Information Modeling*) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition [1]. BIM is connecting the stakeholders: architects, structural engineers, constructors and MEP (abbr. *Mechanical, Electrical and Plumbing*). 3D model is a base point of BIM approach. It includes a lot of information about elements of design and their behavior and relationships. All the information is in one place, which makes the design more efficient and effective. BIM software include cost analysis tools, construction schedule and a realistic visualization. Being able to see in advance all the errors and collisions between elements that would happen in construction saves a lot of time and money in the future. The benefits gained from BIM approach vary depending on the level of BIM implementation which can be seen on Fig. 1.



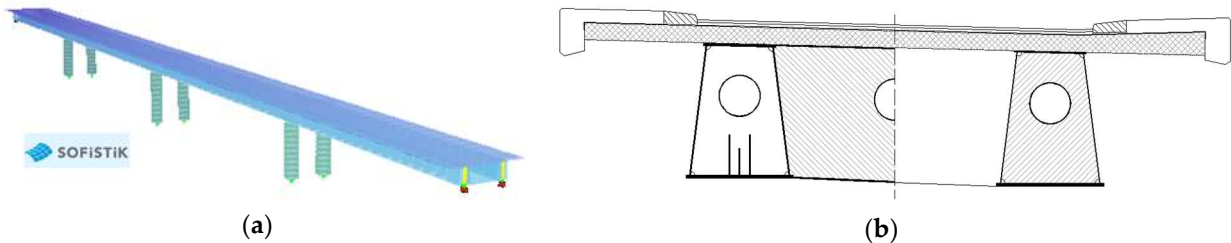
**Figure 1.** Levels of BIM implementation [2]. The level 0 is not a BIM approach, it contains 2D drawings while the communication canals are email and printed copies. The old way of design which is highly inefficient; 1. level is the start of BIM implementation, 2D drawings are mixed with 3D models and the communication is united within one stakeholder's company with a CDE (abbr. *Common Data Environment*); In 2. level there is one CDE which is common for all of the stakeholders. This level is a real BIM approach. The important thing is to have a common data format. The global trend is to use IFC format which is neutral; 3. level is also called iBIM and it contains only one model on which all of the stakeholders are simultaneously working.

The model is online and is constantly updated. This level is still not widely used but will be in the future and will further increase the productivity BIM brings into construction sector.

BIM also stands for *Building Information Management* which implies that BIM approach should be used in all phases of a structure's lifecycle: design, construction and maintenance. Facility management is a new field that supports BIM approach in the phase of a structure's lifecycle which starts after the end of construction and it does not include only repairing, cleaning and maintenance but also structure's lifelong strategic goals. 60-70 percent of the structure's costs is spent in that phase and using BIM approach in it makes is highly beneficial since all the information are transparent and in one place.

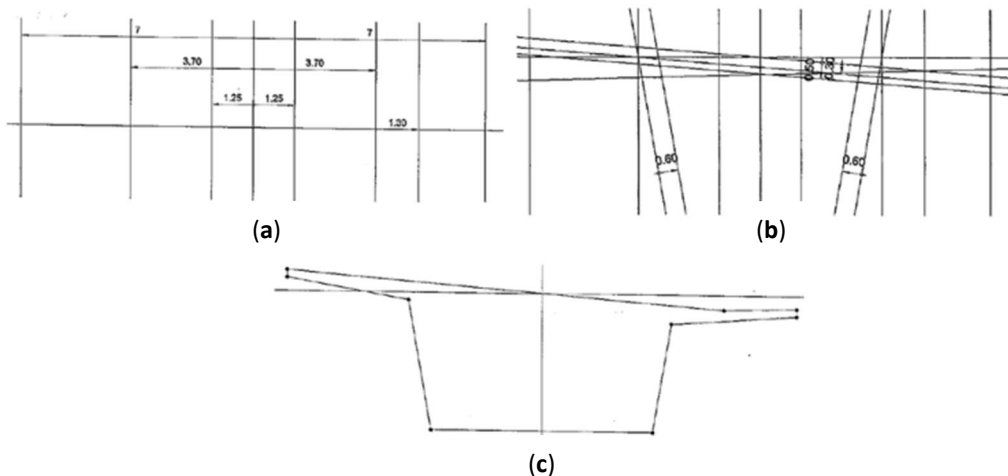
## 2. Methodology

In this paper the BIM approach is demonstrated creating a BIM bridge model in Allplan Bridge. Workflow in that software will be explained with the example of the composite bridge with a concrete deck and two reverse-box steel girders. The bridge was designed and modeled as part of the Master study's curriculum and is shown on Fig. 2.



**Figure 2.** Composite bridge model. (a) 3D model created as a visualization in Sofistik; (b) Bridge cross section drawn in AutoCAD.

First thing that Allplan requires to be done when starting a new model is defining axis which is done by defining axis situation and longitudinal profile. Next step is to attach a cross section to that axis. Cross section is drawn parametrically. It starts with two orthogonal lines and all the other lines are only definable by distance or inclination related to the existing lines. It makes it easy to design longitudinal variations throughout the bridge which makes that software a good implementation in this specific bridge modeled since all the plates that are part of steel girders have a variable thickness. Parametric drawing is shown on Fig. 3.



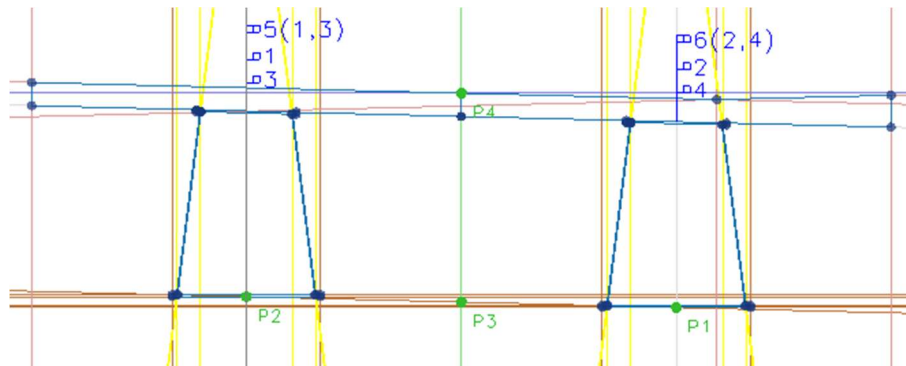
**Figure 3.** Parametric cross section drawing [3]. (a) Lines created with defining a distance to a parallel main axis; (b) Lines created with inclination and distance from the main axis; (c) Final result of a cross section created after defining its borders connecting the lines' intersections and turning the lines' layers off.

The vertical elements are attached to the reference points located on the main girder. This function is used to create piers, foundations and some details. Since piers and girders are the only functions to model elements in Allplan Bridge, those options can also be used to create some details like bearings. The default way to design the additional elements is in Allplan after importing the data created in Allplan Bridge.

Other options available in Allplan Bridge include an animated construction schedule visualization, a tool to export the used material quantities to another software like Microsoft Excel which can be used to calculate structure's cost and a prestressing tool in which it is possible to model tendons with varied shape possibilities.

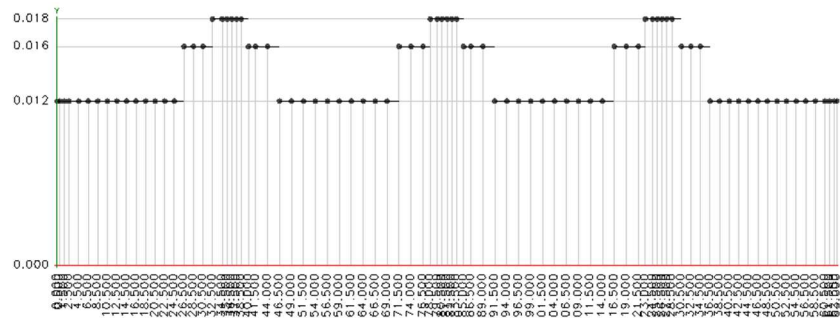
### 3. Results

After defining the bridge axis, a cross section is created with parametric lines. It is important that the inner lines are defined relating to the outer ones in order to keep the outer surface without bumps when the variations are introduced into the model. The main girder cross section can be seen on Fig. 4.



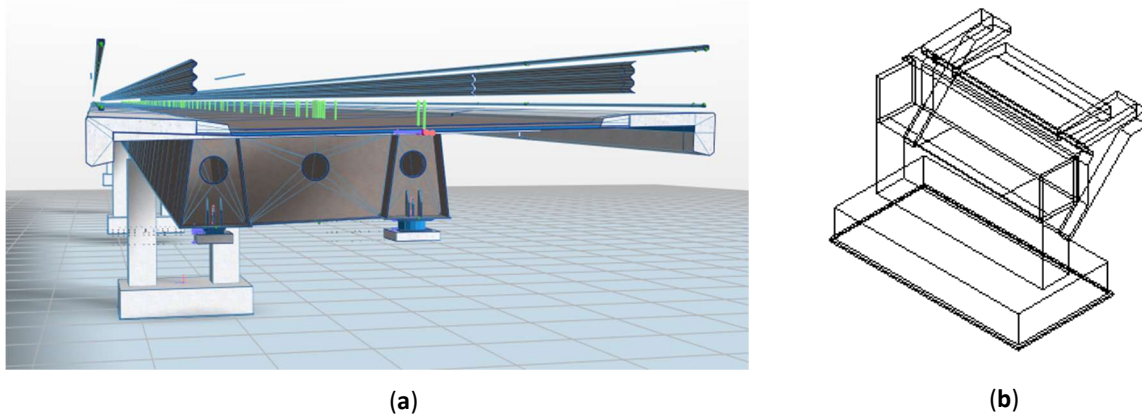
**Figure 4.** Main girder cross section created with the parametric design tool.

As previously mentioned, Allplan Bridge makes it really easy to model longitudinal variations in the cross section. To model them a graph like the one shown on Fig. 5. has to be created. Distance that parametrically defines the line that is being modeled has to be attached to the graph.



**Figure 5.** Longitudinal thickness variation for the main girder's web.

After modeling piers, foundations and some details like bearings with the pier tool, and pedestrian corridor, longitudinal fence's parts, pavement, cornice and stiffeners with the girder tool (Fig. 6.a), it is time to export the model in Allplan. In Allplan the model loses the transparency it has in Allplan Bridge but it is the only way to model essential bridge parts like abutments (Fig 6.b), fences posts, reinforcements, crossing slabs, all parts of the drainage systems, lamp posts and other details if needed.



**Figure 6.** Modeled bridge. (a) Model created in Allplan Bridge ready to import to Allplan where abutments, fence posts, drainage system and reinforcement can be modeled; (b) Abutment modeled in Allplan.

#### 4. Discussion and conclusions

One of the biggest advantages of the used software is that if something like axis is changed, the whole bridge refreshes with one click. That makes it possible to have different bridge templates and with them to model a completely new bridge with much less effort. Also, it is possible to obtain the 'wholeness' of the model which is not possible to obtain with regular 2D drawings and the discrepancy of the model's transparency of information provided between 2D drawings and 3D BIM model is large.

On the other side, the software is still early in development. It is still not possible to export the model in a structural analysis software. The idea is that with very few adjustments it should be possible to get all the analysis results in a structural analysis software with the model created in Allplan Bridge but the function is not yet implemented. Also, the details are not efficient to model and Allplan is not very well adapted to work with bridges. It is noticeably slower and less transparent than Allplan Bridge and lack of colors and depth vision are a degradation in the work environment when transitioning.

Despite those setbacks, this software is proven to still be efficient. With further development of this and other similar software, they will become necessary for the construction sector participants to be competitive in terms of efficiency and quality of models and cooperation.

#### References

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