USING AUTODESK CIVIL 3D IN RAILROAD INFRASTRUCTURE DESIGN

Barbara Belinić
DB Engineering & Consulting, Croatia

Abstract

Due to its great geological and transport position, Croatia is part of important international transport corridors and was included in the Trans-European Transport Network when it joined the European Union. The fact that Gradec-Sveti Ivan Žabno section is the first completed new line in Croatia after 50 years shows how much the railroads in Croatia need revitalization in order to increase railroad capacity, speed and safety level. The next ten years will be marked by investments in rail infrastructure projects worth an estimated 4.4 billion. Due to the large infrastructure projects, such as the investments in the RH1 and RH2 railroad corridors, designers are facing major challenges that require faster, more efficient and accurate planning and successful cooperation between all parties involved in the planning process and construction. BIM (Building Information Modeling) has emerged as an important tool for creating and modifying digital and graphical data in the design, planning and construction phases of a project. This article will present the railroad as an important subject in the demographic and economic development of Croatia and the application of BIM technology in the design of railroad infrastructure in Croatia. Also, through available literature about BIM technology in railroad infrastructure in the world, the article will give an overview of the practical part of the implementation using AutoCAD Civil 3D platform. Current infrastructural projects in Croatia poses numerous challenges to designers due to its complexity. They will serve as an example, illustrating the advantages and disadvantages of using Civil 3D and Subassembly Composer. The article examines the legal regulations for the application of BIM technology in European Union and what can be expected from Croatia in terms of its integration in the future.

Keywords: railways, transport, BIM, Civil 3D, design

1 Introduction

Whether road, rail or sea corridors, Croatia has become part of important international transport routes due to its favorable geographical location as a country on the Adriatic Sea, in Central Europe and on the river of Danube. With the accession to the European Union in 2013, Croatia became a part of the Trans-European Transport Network (TEN-T Network). One of the basic goals and an important condition for the balanced development of all EU members is the connection of the basic transport infrastructure network with the Trans-European networks and corridors [1]. The fact that the Gradec-Sveti Ivan Žabno section is the first newly built railroad line in Croatia to be completed in 50 years [1] speaks volumes about the need for revitalization in Croatia to increase the capacity, speed and safety of the railways.

Croatia is facing a challenging decade with major investments in railroad infrastructure worth about 4.4 billion euros on a length of about 750 km of renovated railroad corridors, most of which will be financed and renovated with European Union funds. While on the RH1 corridor

the length of double-track lines will increase by 82 km, the length of double-track lines on the RH2 corridor will increase by at least 190 km [1].

Precisely because of the demanding infrastructure projects mentioned above, designers in the construction industry are facing major challenges that require faster, efficient, accurate designing and successful collaboration between all parties involved in the designing process and construction. Building Information Modeling (BIM) technology has emerged as an important tool to meet these requirements.

2 Building information modeling

BIM or Building Information Modeling is the process of creating a virtual three-dimensional information model of an object that can be used to create accurate graphical and digital data by inputting specific information.

BIM technology is a process in which progress of the project can be described by dimensions of a particular BIM technology. The most popular is the 3D BIM dimension, where objects are represented in a triple X-Y-Z coordinate system that provides 3D data about a given structure. The article focuses on describing the process of creating 3D dimension through the Autodesk Civil 3D platform. Other dimensions include time orientation, cost estimation, rapid modification of data when changing the structure in the construction phase and defining the maintenance sequence [2].

3 Railway corridor modeling using civil 3D BIM platform

Civil 3D is Autodesk's vertical product for civil engineering design and documentation solution that supports Building Information Modeling workflows of various structures such as roads, highways, railroads, land development, airports and water. The three main objectives of Civil 3D software are processing and analysis of existing data, conceptual and detailed design and creation of construction plans and documentation [3].

The RH2 corridor includes the sections Križevci-Koprivnica-State border, Dugo Selo-Križevci, Hrvatski Leskovac-Karlovac, Karlovac-Oštarije and Škrljevo-Rijeka-Jurdani, making it one of the most important corridors for reconstruction, both financially and in terms of reconstruction works. Railway sections Škrljevo-Rijeka-Jurdani (on the left) and Križevci-Koprivnica (on the right) are shown on Figure 1.

In the following, the process of modeling the railroad is described with a final conclusion about the advantages and disadvantages observed during its use.

Figure 1   Škrljevo-Rijeka-Jurdani and Križevci-Koprivnica railway corridor [1]

3.1 Creating SURFACES

Any design of transport infrastructure, including railroad infrastructure, begins with the data of the terrain on which the construction of the infrastructure object is planned. Before designing the geometric elements of the railroad itself, it is important to create a digital terrain model, determined by triangulation.

Civil 3D recognizes terrain data given from surveyors very well and can create a digital view of the terrain very quickly using variable input data (points, lines, polylines, blocks, text). One of the advantages is also that the terrain can be edited afterwards. Different terrain view and style options allow the designer to have a better view of the terrain and eliminate possible missunderstandings of the 3D space, which can sometimes be confusing in the digital view. These advantages can come into play in projects, where, due to the challenging terrain and numerous existing objects, the 3D digital representation of the terrain can help a better understanding of the space and its changes. The example of the 3D model of the railway bridge is shown on the Figure 2.
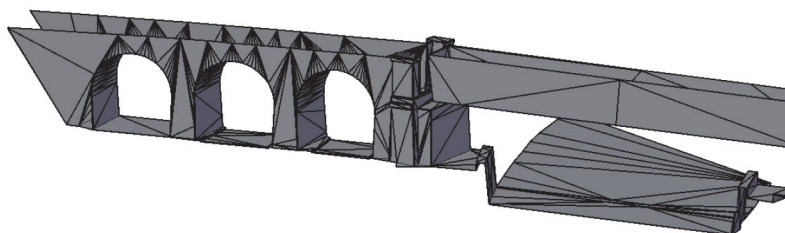

Figure 2   3D model of the railway bridge

3.2 Railway geometry elements

The principle of laying the railroad geometry elements in the horizontal and vertical sense in Civil 3D does not differ significantly from laying geometry elements of railroad in other BIM platforms or other types of infrastructure.

Setting up horizontal and vertical geometry in Civil 3D is quite simple, but some shortcomings were found that can slow down the designer's work. Setting up a more complicated horizontal railroad geometry can be confusing and it takes time to understand it better. Also, the Geometry Editor window can sometimes freeze for unknown reasons and a restart of the file is required.

Vertical geometry with a vertical slope of 90 degrees is also a problem for Civil 3D, which does not recognize an object that can move through space in this way. Such an object can be a retaining wall. It is important to note that changing the horizontal geometry of the route causes problems for Civil 3D, which updates the vertical geometry data, and it is necessary to manually enter the locations of the correct vertical breaks of its geometry.

After setting up the horizontal geometry it is necessary to define cant. After defining design speed and the cant mode (around the left rail, around the right rail, around the track axis) Civil 3D will calculate the cant for each curve. Civil 3D can calculate the required cant with the selection of the appropriate formula that can be manually modified in Calculate Cant window but it is not intelligent enough to choose the ideal cant so that the passage of the train at minimum and maximum speed is ensured.

3.3 Subassembly composer

Autodesk Subassemly Composer is a help-sofware for Autodesk Civil 3D that enables the creation of complex subassemblies, which are 2D cross-sectional views used to model the 3D corridor of an infrastructure object. With the help of the Subassembly Composer software it is possible to create different types of railroad body, embankments, cuttings, different types of drainage channels, retaining walls, platform elements which can be combined and defined differently depending on the design requirements.

Different types of railroad bodies can be made, such as the single-piched and double-piched railroad body on the open part of the corridor and a railroad body at the railway station with one-sided and double-sided platform element. Intelligent slopes were also created, changing their shape into a cut or fill slope with or without berms, depending on the characteristics of the terrain. It is very important to emphasize that Subasemmbly Composer supports the so-called "targeting" different surfaces and objects. This option greatly facilitated the 3D modeling of railway corridors with very demanding terrain. Also, once made, subassemblies can be used for future projects as well. The created subassemblies are assembled into a complete assembly in the Civil 3D program as it is shown on the figures 3 and 4.
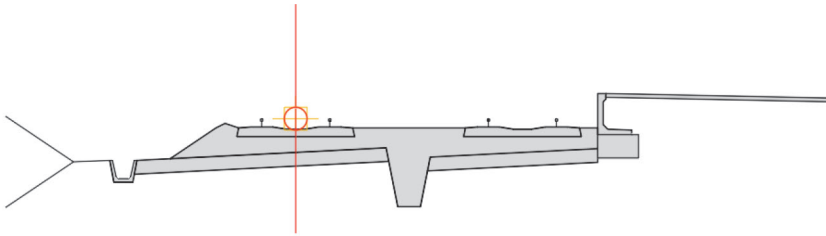

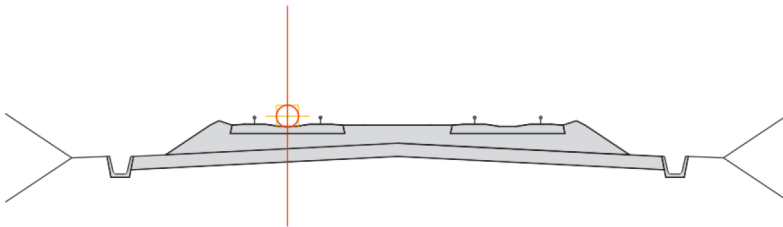**Figure 3** Assemly with one-sided platform element and slope

Figure 4 Assemly with double-piched railway body and slopes

By setting their parameters, the corridor of the route is defined, and their 3D visualization is possible with the Object Viewer option. Figure 5 shows 3D model of railway station with railway body, its cut and fill slopes, platform elements and parking space.

This part of the railway corridor is a great example of collaboration between parking lot designers and designers of the railway corridor as several changes were made to both objects to harmonize their positions. This is the main advantage of using the Civil 3D platform when it comes to the 3D dimension of the BIM technology-this way Civil 3D allowed a faster planning during the collaboration of several designers, an accurate graphic representation and transparency of this part of the railway corridor.
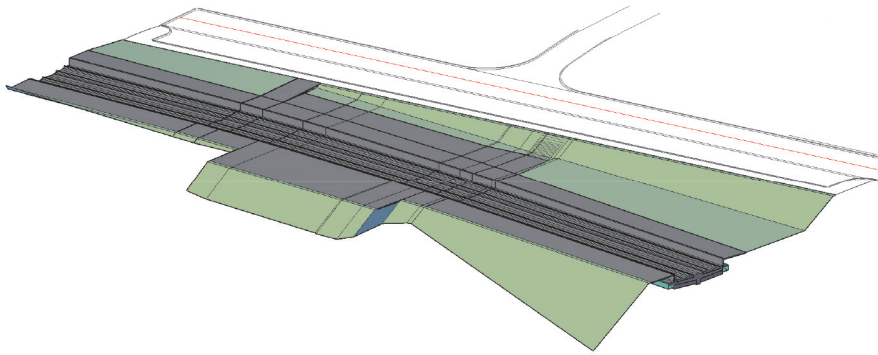
Figure 5   3D model of railway corridor at railway station

3.4 Data shortcuts

Data Shortcuts is a Civil 3D option that allows linking different files and synchronizing them across the files after their modification. The two main processes that enable this operation are the creation of the source files and the consumer files.

This option should be used in such a way that the terrain file, horizontal and vertical geometry elements of a railroad file, the railroad corridor file and the cross sections file were connected. It is important to know that through this connection between files, every change in the source file is updated (synchronized) in a consumer file. In this way, any change in the data will be visible in the last consumer file with cross sections, which helps in further design decisions.

Since the working files are separated, the size of their data is reduced and they can work faster and easier, although the files with cross sections still need more time for synchronization, since the cross sections in some projects should be made every 20 meters.

3.5 Compute materials

Once the final model of the rail line is available, an estimation of excavated material quantities can be calculated. Material quantities will directly influence construction management decisions. Thus, it is in the designer's best interest to provide accurate data to those involved in the project at the construction site, which will ultimately affect construction costs. Thus, when implementing the detailed design, the Compute Materials command was used to calculate the amount of excavated material. The advantage of this option in Civil 3D software is that it is possible to calculate different types of materials (earth material, ballast), depending on the code of subassembly in Subassembly Composer. It is very important to emphasize that the indication of the quantities of materials can be made in the form of a table, and any change in the corridor or the cross section of the route is constantly updated in the table.

4   BIM tehnology regulation

It is easy to talk about all the benefits of BIM technology, but the question is how much is it defined and available to its potential users in each country. Countries such as the United Kingdom and France have mandated the use of BIM Level 2 technology, which is characterized by data-sharing between project participants. Nordic countries have implemented the use of BIM technology in public institutions and larger construction companies also in the phases of use and maintenance of facilities [4].

Unlike the aforementioned countries, Croatia is only at the beginning of implementing BIM technology in its standards. It is expected that Croatia, as a member of the European Union, will soon establish the legal base for the use of BIM technology in accordance with Directive 2014/24/EU of the European Parliament and Council [4].

It is difficult to say when will Croatia be ready for a fully defined BIM technology legislation when BIM Croatian directives themselves are inconsistent. Barriers to meeting BIM standards can be found in the slow adaptation of the construction sector to technological change, insufficient training of workers and low technological development.

5 Conclusion

The application of BIM technology brings various advantages in the realisation of demanding infrastructure projects, such as those currently being carried out in Croatia.

One of the biggest advantages is obtaining a 3D model of the railroad, which can be used to easily identify collisions with the planned objects. This provides better communication between designers and other project participants, saves time in designing process and creates transparency of the project. In addition, this approach can directly show the extent of the impact on the environment and can later be used in different phases of the building's life cycle.

The 3D dimension of BIM 's technology provides accurate digital and precise graphic data, which has resulted in significant savings in the construction process, and Civil 3D has proven its worth on the projects in this article. It should also be mentioned that, as an Autodesk product, Civil 3D's user interface is the same as AutoCAD's, making it easier and more practical for users to adapt.

In addition to the advantages mentioned above, some shortcomings in the use of Civil 3D software in railroad modeling were also noted. Some of them are mentioned in the article in the form of so-called bugs. Also, the slowness in certain program performances is noticed. In addition, the Civil 3D software is quite expensive, which limits the circle of its users.

Also, a major problem is the undefined Croatian BIM regulation due to lack of investment in employee training and computer infrastructure. Professional meetings, seminars and courses organized to introduce the BIM technology to its future users are of great importance and form the base for the implementation of the BIM technology in the national standards of the construction sector in Croatia.

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