

Application of BIM Technology in High-speed Railway Subgrade Engineering

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Abstract: BIM technology is the main technical means to implement the informatization of railway engineering construction. The application and promotion of BIM technology are the primary choice for the implementation of digital railway construction. So far, BIM technology has been widely used in housing construction and other related fields, but it is still at an exploratory stage in the field of high-speed railways. Aiming at the demands for the engineering construction of the high-speed railway subgrade, the paper explores the BIM-based operational flow of high-speed railway subgrade, analyzes the application process of BIM technology, and provides a reference for the application of BIM technology in high-speed railway subgrade engineering. It is necessary to further study the application of high-speed railway BIM technology and increase the secondary development based on BIM technology in the future.

1 INTRODUCTION

Informatization plays an increasingly crucial role in the modernization of China's railway construction. There is a huge demand for the development. To vigorously develop informatization is an important way to modernize China's railway construction. Among them, BIM technology is an advanced information processing tool and is the center of life cycle management of railway engineering [1]. BIM technology is the main technical means for the implementation of informatization of railway engineering construction. Its necessity and value have been recognized by and attracted attention from the industry. The application and promotion of BIM technology is the primary choice for the implementation of digital railway construction. So far, BIM technology has been widely used in housing construction and other related fields, but it is still at an exploratory stage in the field of high-speed railways.

2 APPLICATION STATUS AND MAIN PROBLEMS OF BIM IN HIGH-SPEED RAILWAY ENGINEERING

2.1 Application Status

The application and research of railway BIM is based on the technical requirements. There are no railway standards in the world. This poses great restrictions and obstacles to the promotion and application of BIM in the construction of railway projects. China Railway Corporation began to implement the task of studying the BIM standard system in 2013. So far, China has promulgated the BIM technical standard for railways as Classification and Coding Standards for Railway Engineering Information Models (version 1. 0), etc. [2].

The application of BIM technology in high-speed railway projects of China is still in the exploring stage. It is presented in the research of single-point, single-professional application of BIM technology. At this link, the research and application of BIM

technology have been carried out in lines, subgrades, bridges, tunnels, geological models, and station buildings of some projects, such as the three-dimensional design of a high-speed railway in Western China undertaken by China Railway Eryuan Engineering Group Co., Ltd., the high-speed railway project in the west of Yinchuan, etc., and have achieved excellent results [3]. They cover many types of specialized model component libraries, implement the effective integration of GIS, BIM, and terrain geological model data, and realize the use of informatized construction techniques such as real-time data processing and real-time interaction.

In addition, the application of BIM technology in high-speed rail requires the support of relevant professional software. If there is a need to present BIM value at a very large level, multi-level software is necessary. The paper divides the mainstream BIM software into design modeling, model analysis application and engineering management in accordance with the construction phase of high-speed railway construction, as shown in Table 1.

Table 1 BIM Software Related to Railway Engineering Construction.

Design modeling	Model analysis application	Engineering management
Revit	Navisworks	ProjectWise
ArchiCAD	Infraworks360	ENOVIA
Civil 3D	Lumion	ProjectWise
Bridge		AssetWise
Inventor		Glodon BIM software

2.2 Main Problems

(1) Standard issues

Research on BIM standards worldwide does not cover railroads completely and such researches are still under progress. The current BIM standards are generally applicable to the housing construction industry, and their fields mainly cover: Building structure, electrical, HVAC, construction management, etc., but they cannot cover the unique professional fields in the railway field, such as: Orbit, geographical information, bridge, subgrade, station building, geological environment, tunnel, route and locomotive, etc. The above-mentioned unique professional fields need to be redefined in the preparation of standards. Although the railway BIM

standard system of China can be used for reference and research on foreign standards, the task of expanding is very tedious and difficult. Basic standards such as IFC and IFD are all professional contents, which cannot be undertaken by a common researcher. Only the high-level technicians can solve these problems. Moreover, the railway project is a very special linear project. It mainly presents itself as an effective integration with the terrain and involves a very large geographic area. This requires the integration of the GIS field into the railway BIM standard. However, the effective integration of BIM and GIS has technically increased the difficulty of the work.

(2) Software problems

The current software on the market lacks mature BIM software products in the railway field. Although there are many products based on BIM technology in the world, none of these products can fully meet the regulatory requirements of the Chinese railway industry. In addition, the software architecture does not have linear engineering design elements, and it is difficult for data capacity to support linear engineering applications. Most software products are limited to the point applications, so it is difficult to implement an effective linear design. The railway field has many specialties, and the railway engineering process is particularly tedious and complex. On this basis, the difficulty of applying BIM technology in railway engineering is much greater than that in the construction engineering, especially when the topographic and geological conditions need to be integrated. However, BIM software seldom considers the terrain and geology problems. In order to meet the needs of railway design, we must also devote more energy to the secondary development of the railway system.

(3) Application problem

Domestic and foreign BIM software does not support railway products. Railway products, semi-finished products, and components lack corresponding component libraries. If the existing BIM component library in the construction field is used in the market, it will suffer many limitations in terms of calculation of quantities, information exchange and other levels. Therefore, it is very difficult to construct a standardized BIM component library for the railway industry [4]. In addition, the internal standards of related software suites are not uniform. Due to the large number of software manufacturers, different units do not have the same usage status, making it difficult to exchange data.

3 APPLICATION OF BIM TECHNOLOGY IN HIGH-SPEED RAILWAY SUBGRADE ENGINEERING

3.1 BIM Implementation Process

Considering the management system and investigation of China's railway projects, the author proposes the BIM-based implementation process of subgrade that is led the construction unit and participated by the design, construction, and supervision units. The process of subgrade BIM application model is shown in Figure 1. The application of BIM technology starts from the design phase. The design unit is responsible for the overall application planning of BIM. The construction unit undertakes the responsibility of BIM application and coordinates BIM application management. Finally, multiple parties should be unified in the BIM-based management platform. The construction unit can use the BIM-based management platform to conduct the comprehensive management such as visualized construction progress, cost materials, construction quality and safety, etc. to guide and assist the construction and improve the engineering efficiency. After the project is completed, the project and the completed BIM model will be delivered to the construction unit.

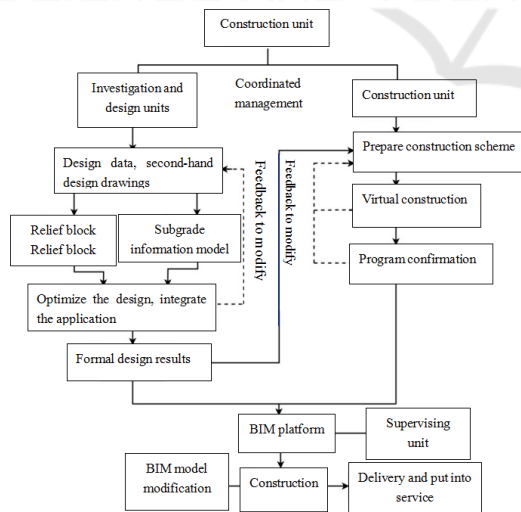


Figure 1 Implementation process of subgrade BIM.

3.2 The Establishment of A New Lightweight Subgrade Model

The overall idea of the modeling process of this project is from the local to the whole and from the bottom to the top. In the entire process of model building, the built-in model in the placement component is used to complete all the details and thus constitutes the entire model. For different parts of materials, especially when the built-in materials of Revit do not meet the requirements, the material parameters are readjusted by data consulting, etc., and the material properties of each kind of plate, high performance concrete, etc. should be consistent with the actual situation as far as possible.

With regard to the establishment of the model, the sand mat at the bottom is first completed, followed by the establishment of a strip foundation, and then a concrete baffle is built above the foundation in the manner of building a slant wall. The baffle is filled with three layers of high-performance concrete as the main body of the subgrade, namely subgrade body, subgrade bed bottom and subgrade bed surface. In the establishment of these irregular cross-section members, the built-in model commands such as stretching, blending and lofting are used for many times to complete the model establishment. The establishment of the upper L-shaped baffle is equivalent to constructing a sand mat at the bottom. The placement of the final track and the grid references to the establishment of irregular cross-section members, thus completing the establishment of the entire lightweight subgrade model. High-speed railway lightweight subgrade model and renderings are shown in Figure 2 and Figure 3.

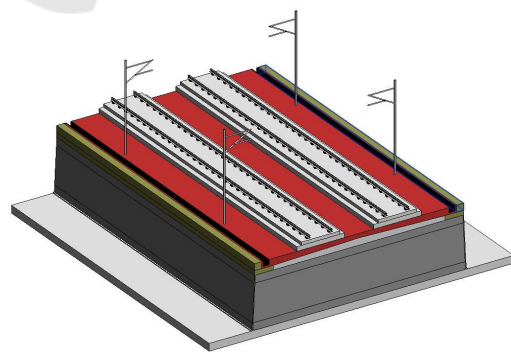


Figure 2 High-speed railway lightweight subgrade model.

Civil3D software can be used to take samples and generate multiple cross-sections covering the topographic surface on the terrain curved surface imported from the outside. The stratum is then filled

in batch according to the cross-sections using the horizontal and vertical relationships. Finally, Civil3D is used to create the physical functions through different curved surfaces to complete the creation of BIM geological model.

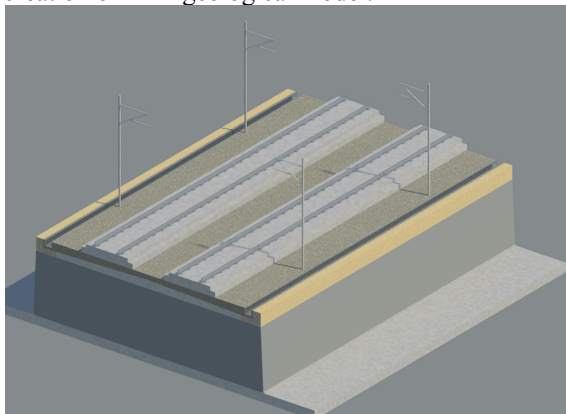


Figure 3 The renderings of high-speed railway lightweight subgrade model.

On this basis, the Civil3D component editor is used to construct the subgrade components according to the visual programming, and then a variety of parameterized subgrade structures are assembled by superimposing according to the different types of subgrade profiles. Finally, the assembled system was used to adaptively generate subgrade models along the terrain curved surface using the three-dimensional lines.

Through the assembly of creation, Civil3D can effectively process the subgrade designs, but the relevant families still need to be created by Revit for the special types of subgrades such as baffles, concrete mixing pile and other structures. Revit uses the model of building a family to establish a subgrade model, but lacks the ability to interact with the terrain, resulting in more difficulties in designing the slope of the roadbed, and creating many families associated with the longitudinal profiles.

3.3 Construction Simulation

Relevant Revit models are imported into Navisworks, and animations are used to express the inflexible construction process vividly and clearly. Compared with the traditional steps, the final intent of the design can be presented more accurately and quickly. The time task items of construction steps that effectively correspond to a model part is

constructed to generate a 4D dynamic model in a virtual simulation environment, and a demonstration of the 9-step basic construction process of the high-speed railway lightweight subgrade is completed. The simulation of the construction process is shown in Figure 4.

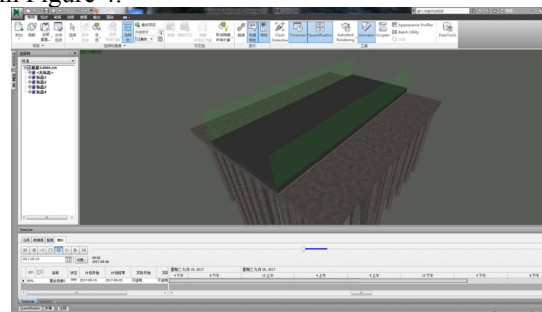


Figure 4 Construction stimulation.

3.4 Calculation of Project Quantity

Relevant Revit models are imported into Navisworks, and the three-dimensional engineering quantity statistics are realized by using the parameter calculation function and the quantity calculation module. The calculation results are shown in Figure 5.

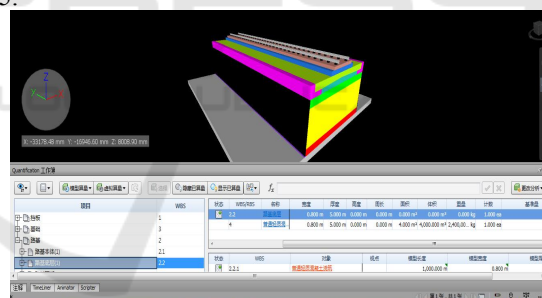


Figure 5 Calculation of engineering quantity.

The engineering quantity statistics are shown in Table 2. In the actual operation, the Navisworks parameter calculation function puts more emphasis on the field of the simple housing construction, and it is not suitable for the subgrade model. The calculation efficiency is not high, and secondary development of the parameter calculation function is required to meet the demand.

Table 2 Main engineering quantity table of lightweight soil subgrade (per kilometer).

		Item	Unit	Quantity
1		L-shaped baffle	m ³	1125
2		Composite baffle	m ³	345
3		Strip foundation	m ³	20
4	The road subgrade	High performance lightweight concrete (650kg/m ³)	m ³	3881.75
5	The bottom of subgrade	Ordinary lightweight concrete (600kg/m ³)	m ³	19093.75
6	The top of subgrade	High performance lightweight concrete (700kg/m ³)	m ³	3747
7	The top of subgrade	High performance lightweight concrete (700kg/m ³)	m ³	1819.84
8		Concrete surface	m ³	2732.66
9		Bed plate	m ³	930
10		Track slab	m ³	525

3.5 Scene Roaming Animation

The project selects Lumion to create roaming animations. This software is very easy to operate and has a good picture rendering effect, which can demonstrate the true environment. Lumion can accept the direct import of mainstream 3D models, such as SU, 3DMAX, DAE and so on. The Revit file can't be imported directly, but it can be imported in Lumion by converting the Revit format to DAE through a plug-in similar as Revit to Lumion Bridge 1.6.1 for Lumion 6. The effect of roaming animation is shown in figure 6.



Figure 6 Roaming animation effect figure.

3.6 Model Integration and Collaborative Design

Considering that many software and standard interfaces are involved in the design of high speed railway subgrade, it can realize integration and application by using Navisworks and other software. There may be many problems in the integration process, such as the model is too large to be imported, the unified coordinates are not available, the file format is not supported, and so on. In order to solve the above problems, different solutions can be used, such as unifying the coordinates in design, adopting lightweight models, using a format

conversion plug-in, conducting relevant secondary development and so on. [5]When it comes the subgrade related professionals such as selection, geology, terrain and so on, the interface level will be more complex. Therefore, in the design of high-speed railway subgrade, it is necessary to emphasize the effective collaborative management among different specialties. In this case, some collaborative engineering software, such as ProjectWise, is needed, which has good cooperative management effect, and can manage the data flow and work flow in railway BIM collaborative design.

4 CONCLUSIONS

Based on BIM technology, this paper explores the BIM operation procedure of high-speed railway subgrade by establishing subgrade model, simulating construction, 3D roaming, and quantity statistics, and analyzes the application process of BIM technology, as well as provides a reference for the application of BIM technology in the subgrade engineering of high speed railway. The related concepts of BIM technology will affect the traditional management process and design pattern. The current audit process and design pattern need to be adjusted according to the characteristics of BIM. It is necessary to further study the application of high-speed railway BIM technology and increase the secondary development based on BIM technology in the future.

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