River Shoreline Project Management Based on BIM Technology: A Case Study of the Environmental Improvement Project of the Green Water Wetland in the Nanjing Reach of the Yangtze River

Tianzeng Huang[1], Haifeng Xu[1], Yanbo Wang[1], Huai Chen[2],
Lei Zhang[3(✉)], and Hongxia Fan[2]

[1] Nanjing Water Planning and Designing, Institute Corporation Limited, Nanjing 210006, China
[2] State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, Nanjing Hydraulic Research Institute, Nanjing 210029, China
chenhuai@nhri.cn, hxfan@hnri.cn
[3] Key Laboratory of Sediment Science and Northern River Training, The Ministry of Water Resources, China Institute of Water Resources and Hydropower Research, Beijing 100038, China
leizhang06@iwhr.com

Abstract. The Building information modeling (BIM) is one of the most promising developments in the architecture, engineering, and construction fields. It carries out the data management during the whole period from site analysis to later operation, and provides technical support and collaborative work platform for a built asset project. Based on the environmental improvement project of the Green-Water Wetland in the Nanjing reach of the Yangtze River, the BIM technology provides a fast and efficient communication platform for all partners involved in the construction period, and has been successfully and efficiently applied in the site design, model analysis, building design, and landscape design. Green-Water Wetland is located on the shoreline of the Nanjing reach of the Yangtze River. The main task of this project is to return the fishpond to the wetland, restore the forest, and improve the landscape of the whole wetland. The specific applications of BIM technology are as follows: (1) It provides a fast and efficient communication platform for all partners involved in the construction period, and couples with the application of GIS and other digital technologies; (2) The Revit and Civil3D software were carried out to realize 3D design of the real scene, and visually display the advantages and disadvantages of each scheme; (3) The preprocessing efficiency of data was greatly improved which lays the foundation for subsequent digital analog analysis; (4) The Mars software was used to render the design scheme in real time, intuitively express the design intention, and avoid repeated design.

Keywords: Shoreline management · Building information modeling (BIM) · Green-Water Wetland · Yangtze River

1   Introduction

BIM (building information modeling) technology was first proposed by Autodesk in 2002 and has been widely recognized by the industry all over the world. It can help realize the integration of building information, from the design, construction and operation of buildings to the end of the whole life cycle of buildings (Vysotskiy et al. 2015).

The core of BIM is to establish a virtual three-dimensional model of construction engineering and use digital technology to provide a complete and actual construction engineering information database for this model (Azhar 2011). The information base contains not only the geometric information, professional attributes and state information describing building components, but also the state information of non-component objects (such as space and motion behavior). Design teams, construction units, facility operation departments, and owners can work together based on BIM to effectively improve work efficiency, save resources, reduce costs, and achieve sustainable development.

BIM is widely used in industrial and civil construction. With the continuous advancement of the concept of smart city, the application of BIM in traditional fields, such as geotechnical and hydraulic engineering, is becoming more and more common, to cite a few (Ismail et al. 2017; Jin et al. 2015; Kalfa 2018; Kumar and Mukherjee 2009; Latiffi et al. 2013).

The model established by BIM has five characteristics: visualization, coordination, simulation, optimization and drawing. At present, the international mainstream BIM design software includes Autodesk Revit series (Demchak et al. 2009), Bentley Architecture series (Logothetis et al. 2015), Graphsoft's ArchiCAD series (Sulbaran et al. 2010), and Dassault's CATIA series (Yang et al. 2019). Taking the Autodesk Revit series as an example, the main softwares including in it are Revit, Civil 3D, Inventor, Naviswork, Infraworks and Lumion. In addition, the Autodesk 3D collaborative design platform Vault Professional provides a collaboration platform for designers. Collaborative design can be carried out on this platform to improve communication efficiency while avoiding collision of components and optimizing design results.

Relying on the Green Water Wetland Conservation and Environmental Improvement Project, this research provides a fast and efficient communication platform for all parties involved in the construction from multiple perspectives and levels. This study is a significant attempt to apply the BIM technology to the River shoreline project management, which has achieved social and economic benefits in the environmental improvement project of the Green-Water Wetland, and shows the prominent future of this technology.

2   Study Area and Methods

2.1   Study Area

Jiangbei New District is located in the north of the Yangtze River in Nanjing City. It is a national-level new district. In order to implement the protection of the Yangtze River,

Jiangbei New District has started the Yangtze River Wetland Protection and Environmental Improvement Project in Jiangbei New District. The Green Water Wetland has a total length of 23 km, and is included in the third-stage project. This project organically combines urban flood control, wetland protection and environmental improvement, and forms a hydrophilic landscape to serve the citizens. This project adopts a comprehensive upgrading method of "cleaning the shoreline, tidying up the river beach, and maintaining the wetlands" to carry out long-term protection of the Yangtze River shoreline in the Jiandbei New District (Tang et al. 2019).

The Green Water Wetland Park is located on the shoreline of the Yangtze River in Jiangbei New District, Nanjing, with a total length of about 12 km and an area of 15.82 km² (Fig. 1). It is an important ecological gateway of Jiangbei New District and an important interface in the spatial relationship among river, city and mountains. Under the overall goal of "the most beautiful shoreline and the nearest future", the protection of Green Water Wetland requires the regulation of water resources, water ecology, water environment, water safety, and water culture. And the goal of this project is to make Green Water Wetland Park the most representative National Park in China.

Fig. 1. The Green Water Wetland in Nanjing, China

2.2   Methods

The main design task of this project is to return fish ponds to wetland, and reorganize fish ponds, water pools, and beaches according to the requirements of habitat creation, water system connectivity and water-land transportation. To meet the requirements of biodiversity and environmental friendship, the entire wetland will be reconstructed and landscaped.

The Green Water Wetland Park is located in the Yangtze River shoreline. It covers a large area, which has complex and diverse regional planning, poor basic conditions, manifold survey contents, and complex water and underwater terrain, and brings great

inconvenience to the designers. To decrease the environmental impact, the earthwork within the project scope needs to achieve the earthwork balance in sub-regions and the overall region. However, the layout of water network, water-land transportation and habitat creation are closely linked with each other, which brings great challenges to the calculation of earthwork balance and the analysis of hydrodynamic and water quality models. Many problems, such as, large design workload, low efficiency and poor verification, are difficult to solve in traditional design models. The landscape requirements of Green Water Wetland project are relatively high, the traditional design cannot verify the design effect in real time and cannot communicate effectively and timely with the construction party, which brings a huge modification workload to the design party.

Therefore, it is particularly necessary to actively explore the application of advanced technologies such as BIM and GIS in the project. By generating 3D digital models from DOM and DEM data, the on-site basic information can be provided intuitively and accurately; by opening up the data interface between 3D digital models and analysis models, the pre-processing workload of traditional analysis models can be greatly reduced, meanwhile the quality of basic data can be improved. Through the rendering and intuitive expression of the BIM model, the effect of landscape design in the project can be displayed and verified in real time.

3   Results

3.1   BIM Application in 3D Real Scene Model

The project covers a large area and is located along the shoreline. There are fish ponds all over the area. The basic conditions are poor and the terrain above and under the water is complex. In addition, the project requires a lot of investigation contents, which makes the site survey extremely difficult. It is impossible to accurately grasp and sort out the site situation only through photos and measurements. The aerial video shot by UAV only has on-site images without terrain data, so it is impossible to analyze the on-site situation thoroughly. Therefore, the study combines the UAV tilt photography and the unmanned ship underwater measurement technology to collect the on-site basic data, and build the three-dimensional real scene model, which lays a foundation for the implementation of subsequent projects and BIM application.

After completing the collection and processing of on-site Digital Orthophoto Map (DOM), Digital Elevation Model data (DEM) and underwater terrain data, the Autodesk RECAP and Context Capture software were used to fuse the data in the same coordinate system. Through the three-dimensional real scene model formed by data fusion (Fig. 2), the topographic and geomorphic patrol and roaming of large scenes and the measurement of elevation, distance and area can be realized. After the model is superimposed, the section cutting at any position is realized, and the section diagram is generated quickly.
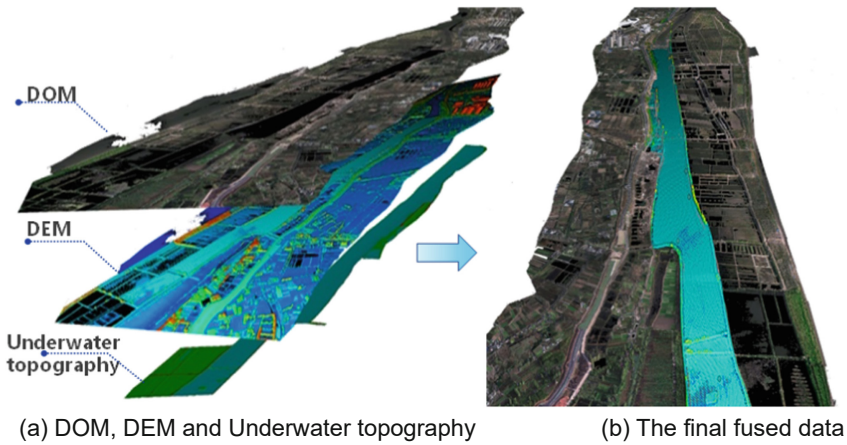
(a) DOM, DEM and Underwater topography   (b) The final fused data

Fig. 2. Data fusion

3.2 BIM Application in Site Design

There are many factors involved in the site layout in the design of this project, such as water network layout, water-land transportation, habitat creation, earthwork balance, etc. These factors all affect the layout of the site. Therefore, this design uses Autodesk Civil3D software for site layout design.

The DEM and underwater terrain data are directly imported into Civil3D to generate the original terrain surface (Fig. 3). Based on the original terrain, the layout of the water network and the design of water-land transportation were carried out. At the same time, the organic combination of habitat creation was taken into account, and the opening and closing changes of the water area were reasonably arranged, as well as the layout and shape of continents, bridges, streams, islands, and embankments.
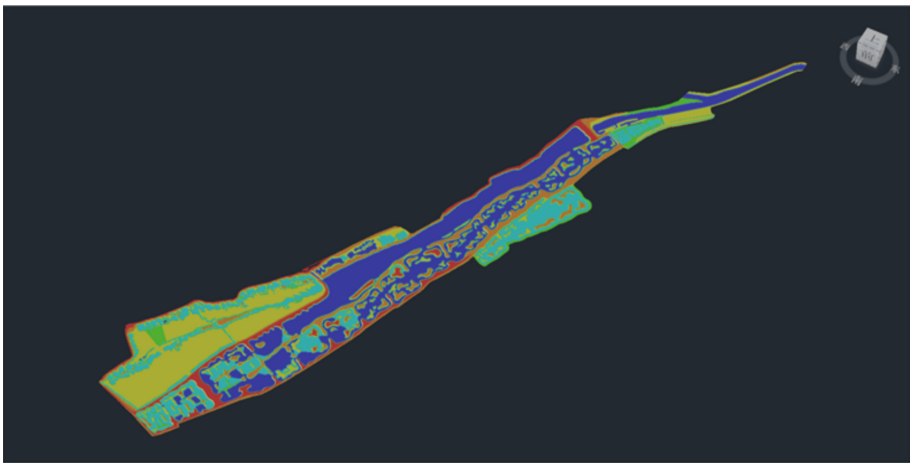
Fig. 3. The 3D terrain model of Green Water Wetland

After completing the design and creation of the entire site model, the elevation analysis function of the Civil3D software was used to analyze the submerged area and semi-submerged area and visually display the dynamic relationship between the sub-merged area and the non-submerged area, and to achieve water system connectivity to meet the needs of water transportation and vegetation (Fig. 4). At the same time, based on the requirements of the protection of the Yangtze River, the project area needs to achieve the basic balance of earthwork in each sub-area and the total balance of earthwork within the entire project scope. The volume panel function was used to quickly calculate the cut and fill volume of each sub area and total area, which not only meets the construction requirements, but also reduces the project investment.

Based on the site model, the current cross-section required for the design of water-land transportation can be quickly cut out. By utilizing the existing roads, the density and direction of the traffic road network can be reasonably set. The Subassembly Composer was used to parametrically design the logical relationship between the road section and the terrain surface, and then quickly create the road model (Fig. 5) according to the route designed in Civil3D, and quickly generate engineering quantities and 2D drawings.
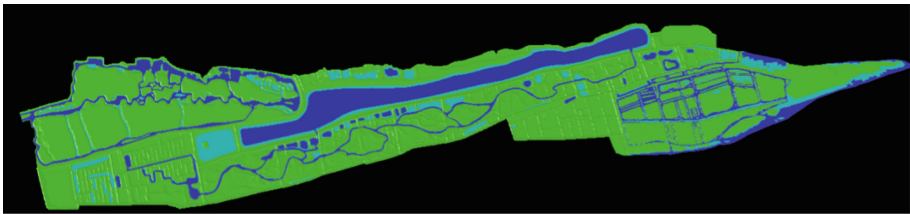
(a) Submerged water level 3.5m
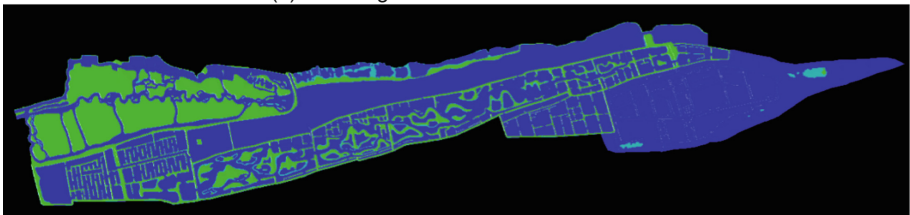
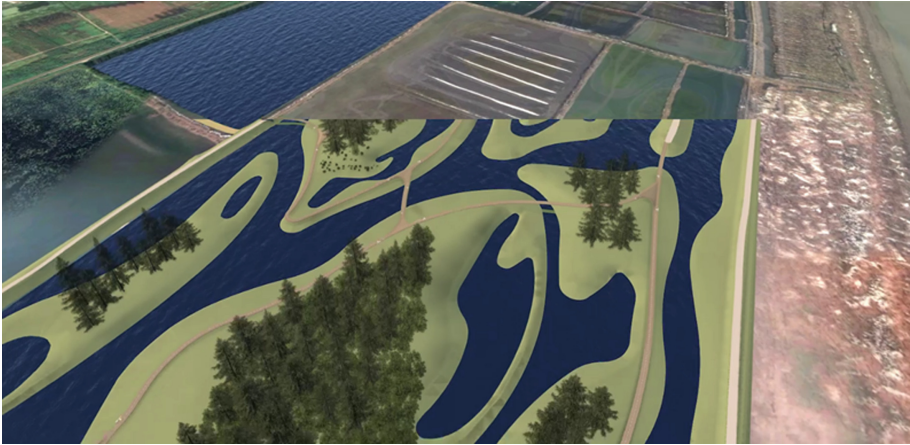(b) Submerged water level 5.5m

Fig. 4. Inundation analysis

Fig. 5. Model rendering

3.3 BIM Application in Model Analysis

This project has high requirements on hydrodynamic conditions and water quality conditions in the region, so verification and analysis of hydrodynamics, water quality and water depth are essential and especially important. There are many designed islands in the project area; the water network is crisscrossed; the deep grooves and shoals are densely distributed, which brings great difficulties to the modeling of analysis and verification. Different water levels will produce different land and water boundaries. The workload to find the boundary is rather cumbersome. The method of Civil3D surface superposition was used to find the water and land boundaries corresponding to different water level elevations, which significantly improves the efficiency (Fig. 6), and provided the basic support for model optimization analysis in the next step (Fig. 7).

3.4 BIM Application in Building Design

In order to solve the problem of water system connectivity, multiple bridges and culverts should be set up to improve the hydrodynamic and water quality conditions in the project area. Based on the Revit software platform, an application set of three-dimensional intelligent design system for culverts and gates was developed (Fig. 8). It can complete the structural layout and detailed structural design of small buildings. Combined with the standardized family library, it can automatically generate 3D models and output 2D structural drawings, which provides a fast, efficient and accurate design solution for small buildings (Fig. 9).
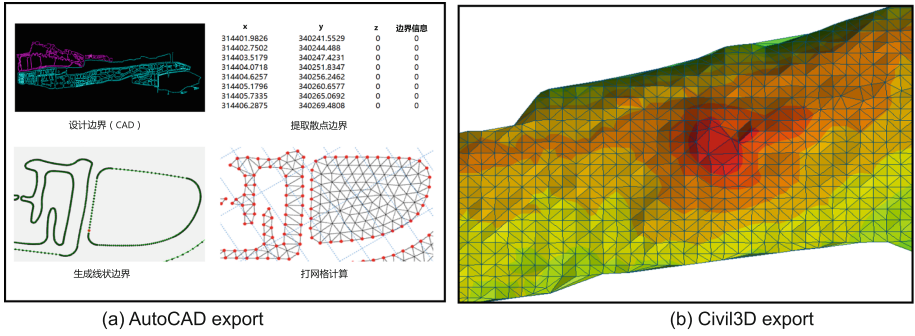
（a) AutoCAD export

（b) Civil3D export

Fig. 6. Export comparison between AutoCAD and Civil3D

(a) before optimization
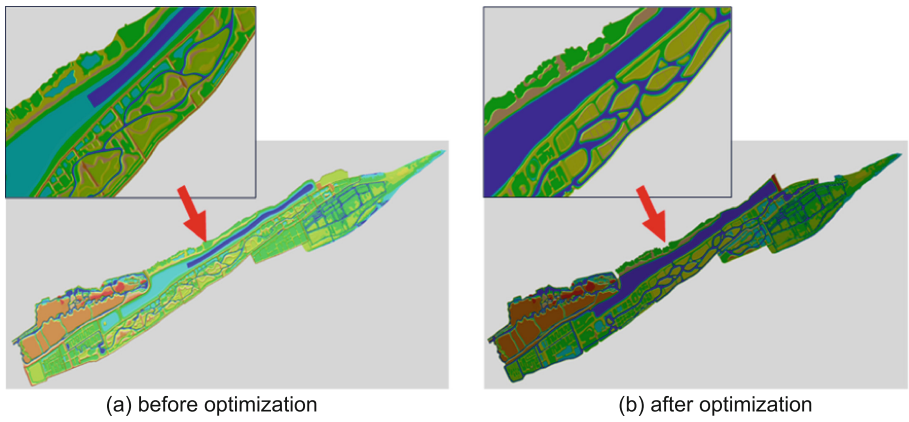
(b) after optimization

Fig. 7. Optimization of water system
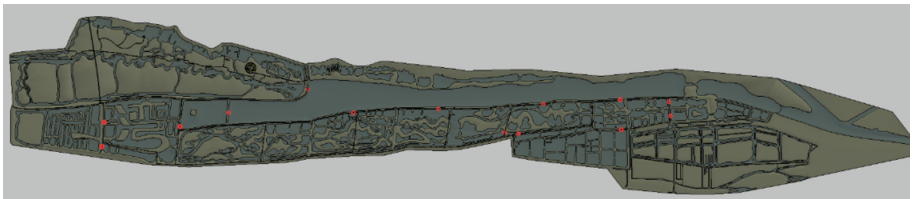

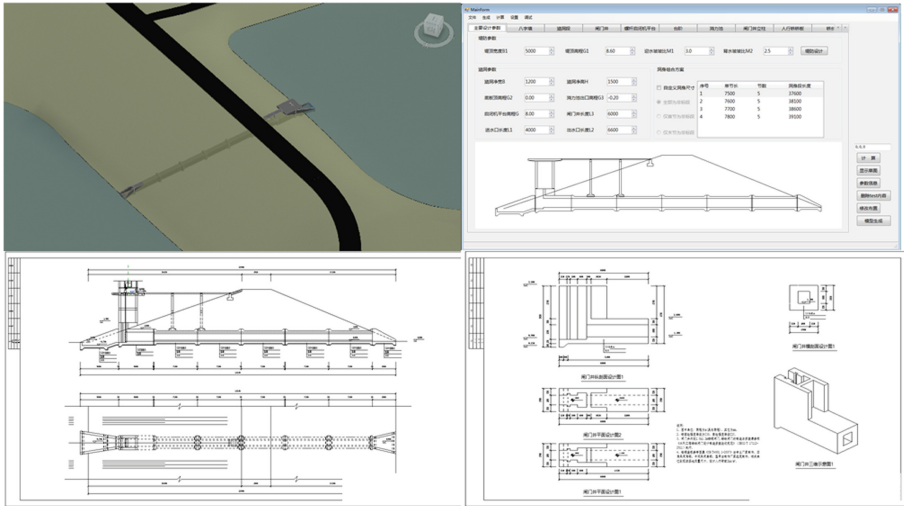**Fig. 8.** Regional distribution of culverts and gates

Fig. 9. 3D model of culvert and gate

3.5   BIM Application in Landscape Design

Combing BIM, GIS, and oblique photography technology, the designed landscape terrain and existing surrounding terrain were fused together. By loading multi-source heterogeneous data, such as, oblique photography, orthophoto, and BIM model in the Mars real-time rendering platform, the rapid restoration of real surrounding scenes was realized (Fig. 10).

The 3D visual planting in the software can intuitively adjust the landscape design scheme, which can realize what you see is what you get, simplify early design and reporting and reduce changes in the later stage of construction (Fig. 11).

Through the plant information model, the information about family, genus, ecological habits and other information of plants can be quickly checked, and tree species were reasonably selected according to the type of plant habitat to ensure the rationality of the design. Meanwhile, tree parameters such as plant height, crown width, and ground diameter at breast height can be adjusted conveniently. Landscape plants arranged in the scenario scene can be exported to EXCEL with a detailed resource list.

The scene can be analyzed from the perspective of human vision. Combined with the compass direction to simulate the real sunshine situation, the planting density and gradation can be adjusted in real time (Fig. 12).
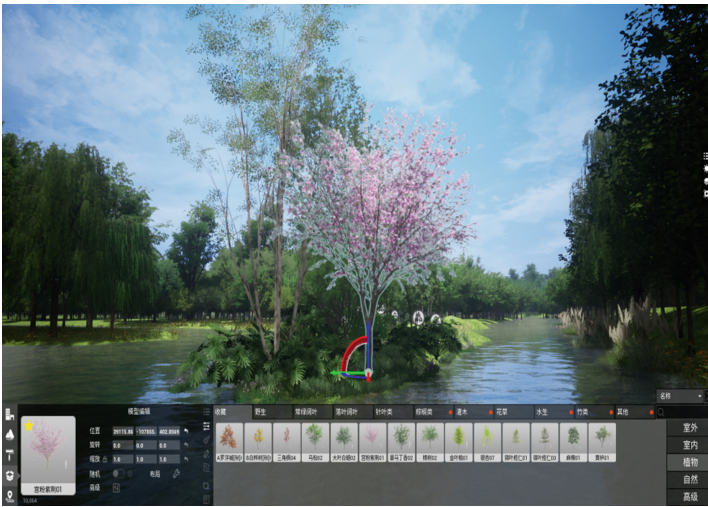
Fig. 10. Real-time rendering of landscape design

Fig. 11. 3D visual planting with a vegetation resource list

Fig. 12. (a) Scene analysis from human perspective and (b) sunshine illumination simulation

4   Conclusions

Caused by complexity of the terrain of river shorelines and the diversity of regional planning, difficulties occur in on-site surveys and data collection, resulting in incomprehensible and inaccurate analysis, low design accuracy, and repeated plan revisions. Taking the Green Water Wetland project as an example, this study explores the application of digital technologies such as BIM and GIS. Revit and Civil3D software were used to carry out real 3D design, and intuitively display the advantages and disadvantages of each scheme. With the support of BIM technology, the pre-processing efficiency of data has been greatly improved, and unnecessary errors caused by manual data processing was also avoided, laying a foundation for subsequent digital-analog analysis. The Mars real-time rendering software was used to render the design plan in real time, express the design intent intuitively, and avoid design repetition.

Through the application of BIM technology in the Green Water Wetland project, the design quality can be effectively improved, and the design results can be displayed from multiple perspectives and dimensions, providing a fast and efficient communication platform for all parties involved in the construction. It is a useful attempt in the project, which has important guiding significance for the research and design in similar fields.

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