



CCCC Highway Consultants use openBIM for the maintenance of a bridge across the Yangtze



About the Project

The Third Nanjing Yangtze Bridge is a 4.7-kilometer cable-stayed bridge across the Yangtze River. The bridge was opened in 2005 and is the third bridge over the Yangtze at Nanjing. Its six lanes carry traffic from the G42 Shanghai–Chengdu Expressway and the G2501 Nanjing Ring Expressway.

In 2017, the bridge owner engaged CCCC Highway Consultants to develop an asset management system—a data entry, display, and management platform that would continuously manage asset performance and maintenance activities. The goal of the system was to standardize and record information and actions related to ongoing maintenance, thus establishing a lifecycle data chain for each asset component.

Moreover, the owner could use the platform and its maintenance data to support decisions regarding the timing and sequence of component inspections, repairs, and replacements. This would help the owner increase safety while lowering maintenance costs and develop more data-driven, evidence-based maintenance management programs and plans in the future.

The owner wanted the system to be highly intuitive for its maintenance staff, particularly when locating bridge components. Therefore, they wanted users to be able to see a display of the bridge structure on their screen—enabling them to visually navigate and locate bridge components.

System Design

CCCC Highway Consultants developed the asset management system using the Unity engine. Unity is a real-time development platform with 3D data import and optimization tools used by development teams to create interactive, immersive experiences based on digital models. The system can be accessed via a desktop or web-based client, as well as a mobile app for maintenance data input and

display. Other existing systems of the owner that were relevant to maintenance (such as document management, health monitoring, and office automation systems) have been integrated with the maintenance platform.

The bridge was designed and built using conventional 2D tools and processes. As a result, there were no 3D models of the bridge available to CCCC Highway's development team, and they had to create a model of the bridge from scratch. The team used BIM software—Autodesk Revit—for their modeling efforts. Model import tools and IFC open standards were used to transfer the BIM models and underlying metadata into the maintenance system.

Model creation

CCCC Highway Consultants used Revit to generate a 3D model of the full length of the bridge. This master model is composed of tens of thousands of component models. These models include graphical representations of the components as well as attributes related to the individual components, such as material type, construction/installation date, manufacturer, and so forth. The component models also include links to related project data and documents, and applicable design and construction/installation drawings.

The accuracy and content of the model is based on the owner's maintenance management needs. In general, the accuracy model is at Level of Detail 300 (LOD 300). This accuracy matches the construction documents that were used to build the bridge. The model contains accurate dimensions, location, quantities, and orientation of the bridge components. Also, the interfaces and connections between the various components are graphically represented. It should be noted that components not needing maintenance management are not represented in the model, which makes the model lighter and improves graphic display times in the Unity engine.

Overview:

CCCC Highway Consultants

Location:

Nanjing, China

Objectives:

Develop a maintenance management system with 3D model display capabilities

Software used:

CATIA, Revit, Unity, XBIM

buildingSMART tools:

IFC2x3

China's CCCC Highway Consultants Co., Ltd. developed an asset management system that standardized and captured maintenance processes and data for the Third Nanjing Yangtze Bridge.

Highlights:

- A virtual 3D model allows users to visually navigate the bridge structure and locate components.
- The bridge was designed and built using 2D approaches, so BIM software was used to create a model of the bridge, post-construction.
- IFC open standards were used to transfer BIM data into the maintenance system.

The components in the bridge models were classified and coded to ensure better information exchange and sharing. ISO 12006-2, an international standard dealing with the structuring of projects, was the classification standard used during the modeling process.

openBIM strategies

Once the bridge was fully modeled in Revit, CCCC Highway Consultants moved all of the information into its newly-developed Unity asset management system. Currently, there is a direct link between Unity and Revit, and the Unity platform supports the IFC standard. But during CCCC Highway's Consultants development efforts, this was not the case. So the team used a two-step process.

First, they used a Revit "Export to Unity" plugin to export the bridge's geometrical/graphical information from Revit to the OBJ file format (an open geometry definition file format). This OBJ file was then imported into Unity. Once the model was in Unity, the team used Unity post-processing features to improve the quality and display time of the model graphics in Unity.

Next, all of the non-graphic attributes and classification codes needed to be transferred from the Revit model to Unity. So the team exported the models to the IFC format using standard Revit export tools. Then they used xBIM (eXtensible Building Information Modeling)—a .NET open-source software development BIM toolkit that supports IFC standards—to extract and import the IFC data required by the Unity-based maintenance management system.



With component IDs as the index, the geometric models and data were all linked in the Unity database (based on the division and basic information of the IFC standard), with all of the component's original geometric dimensions, positions, relationships, and attributes restored.

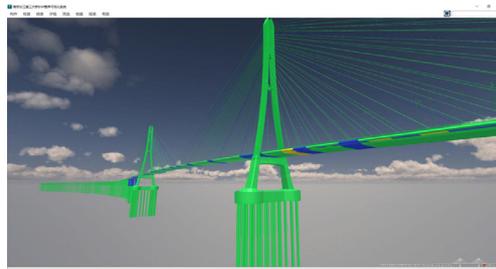
Maintenance operations

During ongoing bridge maintenance, the asset management system is used for standardized entry of maintenance data relating to defects, inspections, repairs, and technical status/ratings. Unlike the original static attribute data imported from the 3D model, this data represents the dynamic attributes of the bridge components that are changing over time.

The owner uses the system to manage, locate, and intuitively display the model and its underlying maintenance data. This includes information inherited from the original IFC files, as well as the dynamic information added during management and maintenance. Powerful search capabilities give users the ability to query static and dynamic component attributes to support their ongoing bridge maintenance efforts such as reporting or graphical display of defect and maintenance data, or statistical analyses of component data.

For example, when a specific component is inspected, it is assigned a technical condition rating. These ratings can be queried and output in textual reports, or displayed graphically by automatically color-coding bridge components based on their rating.

In addition to standard model operation (such as zooming or panning), the Unity platform also has roaming modes such as fly arounds and walk overs. In addition, bridge components can be located quickly in a variety of methods, including visual navigation, component tree selection, and fuzzy searches.



Results

The owner has realized significant maintenance efficiency improvements and cost savings through the use of their asset management system. The maintenance data and activities recorded in the system—data related to a component's defects, inspections, and repairs—can be quickly queried and displayed.

This fast and accurate reporting has reduced the time spent searching for information necessary for ongoing component maintenance by an estimated 30 percent. In addition, the time spent locating specific defective components, researching data related to those components, and formulating a maintenance plan has been reduced by an estimated 50 percent.

And in the future, the owner is contemplating expanded uses of their asset management system. For example, since the Unity platform supports virtual reality experiences, the system could be used to orient and train new maintenance staff. And the data stored and compiled by the system can be used for a broader big data analysis of their management and maintenance performance.

"The system we developed for the bridge owner can be used for a variety of infrastructure types, such as bridges, tunnels, and roads. And virtual models from a variety of BIM authoring tools—such as Revit, Civil 3D, CATIA or MicroStation—can be imported into the system. Regardless of the infrastructure type or authoring tool, the IFC standard provides an excellent channel for data transmission and is a critical part of our openBIM strategy."

Zhunhua Li,
Department Manager,
CCCC Highway Consultants
CO., Ltd.

For more information about buildingSMART International, please visit:

www.buildingSMART.org

Or contact us:

Email: contact@buildingSMART.org

Tel: +44 923 277953