Case Study

U.S. Department of Transportation
Federal Highway Administration

AGENCY:
Iowa Department of Transportation

LOCATION:
I-80 at I-380 near Iowa City, IA

REGION:
Midwest

I-80 EASTBOUND RAMPS AT I-380

3D MODEL DELIVERABLE

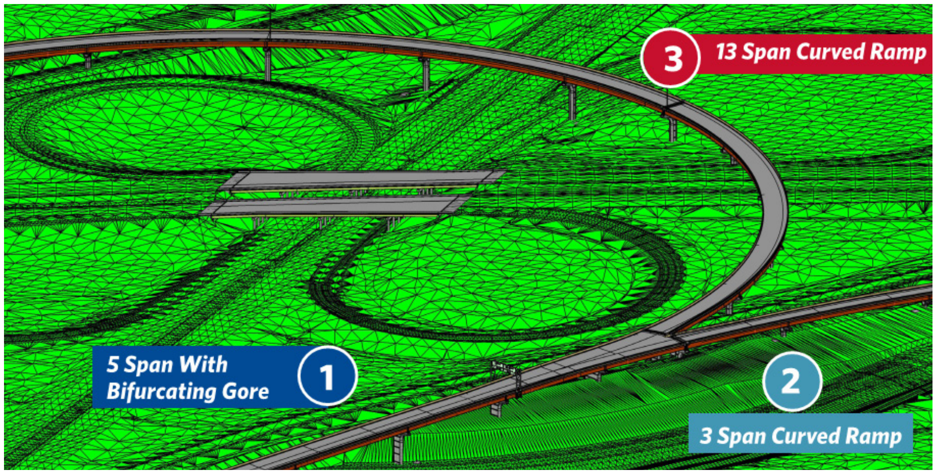

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Figure 1. Project layout

PROJECT OVERVIEW

The interchange of I-80 and I-380 near Iowa City, Iowa, underwent a comprehensive redesign to replace the conventional cloverleaf design with high-speed ramps and flyovers. The project started in August 2018 and is scheduled to be completed by December 2022. The Iowa Department of Transportation (DOT) recognized the opportunity to develop its three-dimensional (3D) modeling program and selected three multispan flyover structures—Ramps 1, 2, and 3, as shown in Figure 1—as a pilot project.

The first was a five-span steel structure that included a gore with complicated, individual, vertical profiles for the diverging ramps. The second consisted of a three-span curved steel structure that comprised the I-80 eastbound to I-380 southbound section. The third involved 13 spans "flying over" both I-380 and I-80 to provide access to I-380 northbound.

These complex steel plate girder bridges, which combined are more than 4,200 ft. long, required a complex superelevation solution and the use of discontinuous girders. Between each girder, the design called for inspection walkways with access portals at each diaphragm. Various aesthetic components were also used throughout the structures, most notably in the abutments and piers.

BIM FOR INFRASTRUCTURE APPROACH

The project established the elements to be modeled, starting with all essential design objects and assemblies, followed by the construction elements, and finally the fabrication elements. Once the lists were completed, a team from each discipline was assigned to develop and model their elements, objects, and assemblies. The following disciplines were involved:

- Geotechnical
- Roadway
- Drainage
- Lighting
- Utilities

The modeling teams were overseen by the building information modeling (BIM) manager, who maintained a single file, which referenced all of the individual models. This one file, referred to as the federated model, was used for clash detection, design review, and overall quality control.

Iowa DOT project leaders wanted to understand just how the contractor would use this federated model during construction, which meant the model would need to provide a detailed visual representation of the structures. To address this need, the team's effort focused on a final design level of development (LOD) of 300 for all design objects.

The BIMForum (https://bimforum.org) describes the LOD Specification as a reference that enables practitioners in the architecture, engineering, and construction (AEC) industry to specify and articulate, with a high level of clarity, the content and reliability of their design models at various stages during the design and construction processes (AGC of America 2019).

All construction elements also carry the same LOD given their geometry and position being based on and modeled by the design team. This is also true with fabrication elements. The initial model element breakdown is shown in Figure 2.

The project team worked closely with the various disciplines to incorporate each model into an all-inclusive federated file. As issues were identified, the appropriate parties worked toward a resolution.

One such conflict involved a pier footing on Ramp 3 and a mechanically stabilized earth (MSE) wall included in a future stage of construction. The footing pile arrangement was altered and the footing was chamfered to provide future clearance between the two elements.

Table of Elements

Document Release: 2-0

Level of Development (LOD,) Grade, and Model Element Author (MEA)

	Model Elements			CONSTRUCTION DOCUMENTATION			CONSTRUCTION			AS-BUILT				
20	Lev	Element Id	Included in Project Scop	LOD (CD)	Grade (CD)	MEA (CD)	LOD (CON.)	Grade (CON.)	MEA (CON.)	LOD (AB)	Grade (AB)	MEA (AB)	Add Data Spec	Notes
665	Level 1	TRANSPORTATION	Yes											
666	Level 2	Roadway Pavement	Yes											
667	Level 3	Roadway Pavement	Yes											
668	Level 4	Conventional Road Pavement	Yes	300	A		350							
669	Level 4	Freeway and Expressway Pavement	Yes	300	A		350							
670	Level 4	Median, Island, and Shoulder Pavement	Yes	300	A		350							
671	Level 4	Roadway Curbs and Gutters	Yes	300	A		350							
672	Level 3	Roadway Signaling and Control Equipment	Yes											
674	Level 4	Roadway Traffic Control Signage	Yes	200	C		350							
676	Level 4	Roadway Markings	Yes	200	C		350							
678	Level 4	Roadway Barriers	Yes	300	A		350							
685	Level 3	Roadway Support Systems	Yes											
686	Level 4	Roadway Lighting	Yes	300	A		350							
687	Level 4	Roadway Drainage Systems	Yes	300	A		350							
690	Level 2	FREIGHT AND PASSENGER RAILROADS	Yes											
691	Level 3	Railroad Trackwork	Yes				350							
692	Level 4	Railroad Track Foundations	Yes	200	A		350							
693	Level 4	Ballasted Trackwork	Yes	200	A		350							
739	Level 2	Bridges	Yes											
740	Level 3	Bridge Substructure	Yes											
741	Level 4	Bridge Foundation Piling	Yes	350	A		400							
742	Level 4	Wingwalls	Yes	350	A		350							
743	Level 4	Bridge Foundation Footings	Yes	350	A		350							
744	Level 4	Bridge Abutments	Yes	350	A		350							
745	Level 4	Bridge Piers and Bents	Yes	350	A		350							
753	Level 3	Bridge Superstructure	Yes											
754	Level 4	Bridge Decks and Deck Supports	Yes	350	A		350							
756	Level 4	Bridge Beams	Yes	350	A		400							
757	Level 4	Girders	Yes	300	A		400							
761	Level 4	Bridge Joints	Yes	300	A		400							
762	Level 4	Bridge Bearings	Yes	300	A		400							
763	Level 4	Bridge Median Barriers	Yes	350	A		350							
765	Level 3	Bridge Signaling and Control	Yes											
768	Level 4	Bridge Signage	Yes	200	A		400							
769	Level 4	Bridge Traffic Barriers	Yes	350	A		350							
770	Level 3	Bridge Appurtenances	Yes											
771	Level 4	Bridge Approach Slabs	Yes	350	A		350							
774	Level 4	Bridge Noise Walls	Yes	200	A		350							
776	Level 3	Bridge Ancillary Systems	Yes											
777	Level 4	Bridge Lighting	Yes	300	A		350							
778	Level 4	Bridge Drainage Systems	Yes	300	A		350							
782	Level 3	Bridge Decks	Yes											
785	Level 4	Concrete Bridge Decks	Yes	350	A		350							
787	Level 4	Wearing Surfaces	Yes	300	A		350							
788	Level 4	Bridge Barriers	Yes	350	A		350							
790	Level 4	Curb	Yes	300	A		350							

Figure 2. Model element breakdown

Table 1. Selected project software

Software	Version	Use
OpenBridge Modeler™	V8i	Basic bridge superstructure elements, foundations and piles
ProStructures™	V8i	Reinforcement, inspection walkways, detailed connections, misc. detailing
MicroStation CONNECT™	CONNECT Edition	Misc. solids modeling and creation of element properties through “Item Types”
i-Model Transformer™	V8i	Property list filtering for final deliverable
ProjectWise™	CONNECT Edition	Common data environment

MODEL DEVELOPMENT

The software reviewed for this project had to perform at a level that would satisfy the main project goals to provide sufficient detail to test its ability and performance and encourage use of the model by contractors during construction. Due to the Iowa DOT’s familiarity with Bentley® Systems software, the programs listed in Table 1 were selected for use and evaluation on this pilot project.

Modeling began with development of the superstructure. The project alignment was imported into the OpenBridge Modeler™ file, and abutment and pier locations were established. The workflow allows the author to select 3D parametric templates to be placed either at a location or swept along the alignment. The number and spacing of the girders are selected, and their lengths are determined by the placement of the abutment and pier lines.

Due to the unique design of the Iowa DOT’s abutments and piers, the entire form was modeled with solids in MicroStation CONNECT™. Care was taken to develop the pier models in a way that would allow for manipulation through varying superelevation sections. Height was also adjusted at each location.

INDUSTRY INVOLVEMENT/PARTICIPATION

Involvement with the Association of General Contractors (AGC) of Iowa began early in the project with a discussion of the proposed modeling effort and the subsequent deliverable. Once the model was complete, the Iowa DOT organized a follow-on meeting with members of the AGC of Iowa, the designer, and State bridge personnel.

The designer was asked to walk through the development of the model and demonstrate the model’s accuracy and the availability of data. After the presentation, contractors were asked if they would use this model during construction. The contractors’ response indicated that without the proper tools and expertise they would have difficulty gaining value from the model. They did, however, state that the model would be a valuable asset for public involvement and in-house orientation to the project.

Iowa DOT representatives agreed there was a need for software and training consideration within the contract due to BIM for infrastructure being in such an early stage of development. The designer held an in-person training session for Iowa DOT personnel and offered it to any interested bidders. The training covered navigation and basic data extraction. The designer also recorded a one-hour training video and made it available online to any potential bidders that did not make it to the training session. The training was well received by both DOT personnel and the contracting community.

RESULTS

The digital delivery of this project was made possible by a special provision developed by the Iowa DOT. This provision required a complete list of all files with instructions on how to access them, along with a list of recommended software to be used to work with the files.

The model element breakdown list showing final LOD dispositions was also supplied. This list was key for defining objects that the designer was not able to model precisely to match the design intent. An appendix was added that allowed the engineer to sign and seal the model declaring it as the primary deliverable with all other documentation that was submitted being for information only.

CONTRACTOR BIDDING

The final bid package contained an i-model for the model deliverable. An i-model is a repackaged, read-only MicroStation™ file that can be opened or referenced using Bentley® products. This file format gave the designer better control over element information and eliminated the potential for modification.

Once the project was awarded, the designer provided the contractor with native (.dgn) files to give them full access to the modeled objects. Full plan sets along with the 3D models were delivered for the two bridges not modeled using the software.

LESSONS LEARNED

The designers learned quite a few lessons as they worked through the details for the modeling effort. The most important take-away was that any BIM effort will involve more than one software program to complete. The fact that OpenBridge Modeler™ was only able to contribute basic model objects left the designer searching for a work-around. The inability to transfer the reinforcing steel bar model to the fabricator showed that it is important to research the local fabricator's equipment and determine compatibility prior to software selection. And, finally, collaboration with the construction industry during the process led to a better understanding of the project and the technology used to develop it.

It was found during this project that, given quality software products and adequate training, the industry will have the technology and expertise to develop successful workflows. As the DOT encourages the local construction industry to utilize the innovations of BIM for Infrastructure, its resources become more accustomed to the process.

REFERENCE

Associated General Contractors (AGC) of America, Inc. 2019. 2019 Level of Development (LOD) Specification Part I & Commentary for Building Information Models and Data. *BIMFORUM*, April. https://bimforum.agc.org/lod/.

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DISTRIBUTION AND AVAILABILITY
This case study can be found at https://www.fhwa.dot.gov/construction/bim/.

KEY WORDS
BIM case study, BIM pilot project, bridge ramp BIM, building information modeling, I-80 to I-380 ramps, Iowa BIM pilot

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