PERSPECTIVE

The Benefits of BIM for Bridge Design and Construction

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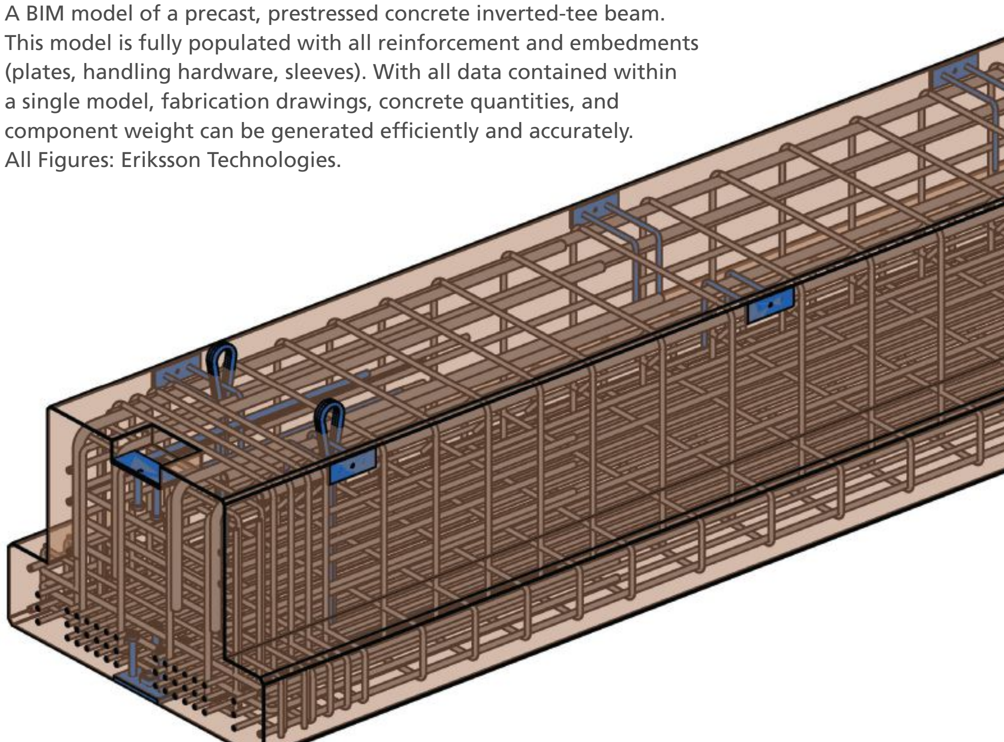
The use of building information modeling (BIM) has become widespread in the world of commercial structures. Entire projects are being planned, designed, and delivered using BIM technology to great success. BIM is no longer viewed as a novel or alternative way of delivering projects. The benefits realized and the efficiencies gained by its full integration into project workflows have made it indispensable for project delivery. In our practice, we have seen firsthand what BIM can do and, with several years of successful experiences, we have embraced it with open arms.

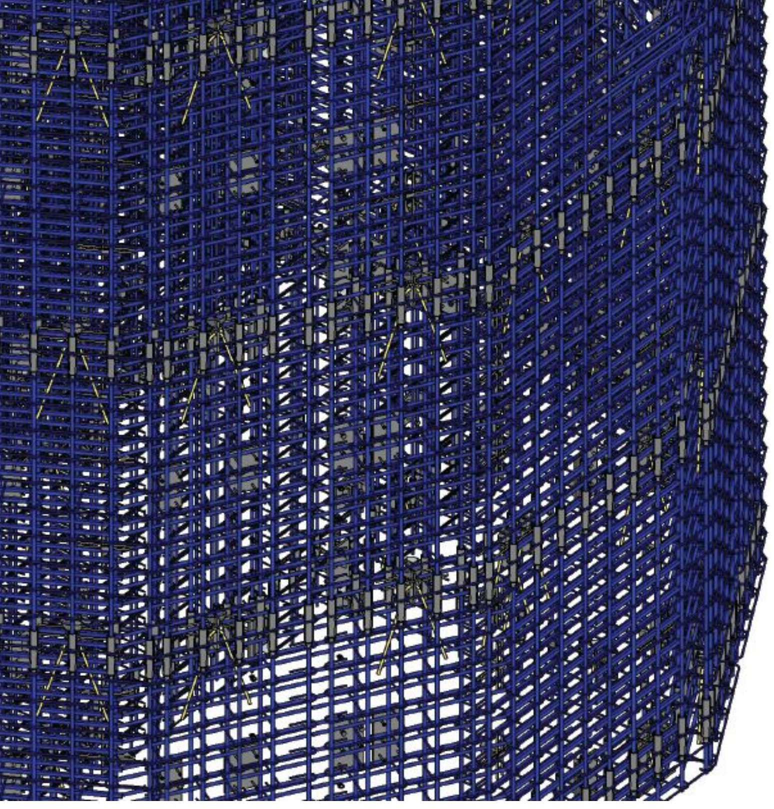
However, BIM implementation in bridge design and construction is still in its early stages. Relatively few projects have been delivered end to end using BIM. The transportation agencies that are making progress in its adoption seem to be focusing first on delivering contract documents as a three-dimensional (3-D) model rather than as a conventional set of 2-D drawings. This, of course, is a necessary early stage of BIM delivery, but it barely scratches the surface of BIM's full potential. Some consulting engineering firms are making progress implementing design in BIM, but they seem to have not yet found firm footing in delivering the type of information needed to construct a bridge structure or fabricate the individual structural components (such as precast concrete girders).

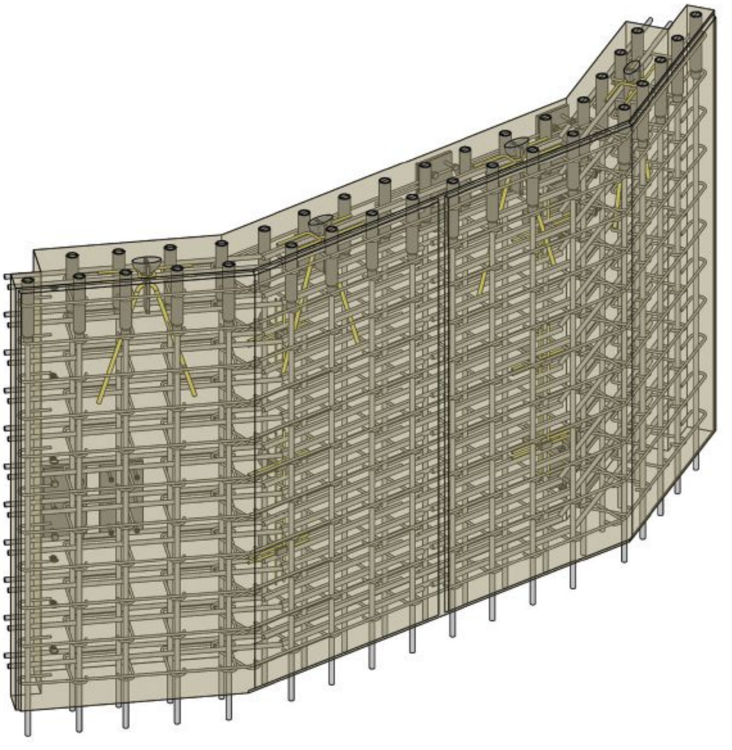
The timeline of a BIM model can cover every phase of the project, beginning as early as the conceptual phase of bridge design and extending all the way to the end of the bridge's useful life. From a practical point of view, the useful model begins once the basic type of bridge has been established. The geometry of the bridge comes first, followed by structural framing and preliminary structural component type and size selection. BIM modelers typically create the model, and once sufficient detail has been included, bridge engineers can begin their work of analyzing the structure and designing the structural components. Detailing follows, as reinforcement and structural embedments and attachments are designed, detailed, and added to the model. Other stakeholders can now begin to interface with the model and add their enhancements, such as lighting, drains, and so forth. At this point, the model starts to become a comprehensive repository for all the information about the bridge, and is now referred to as a federated model. The model is the nonredundant central repository for data, also known as the "single source of truth." All stakeholders must ensure that there are no conflicts within their parts or between their parts and other stakeholders' parts. The BIM manager for the overall project should ensure that all stakeholders have done their jobs.

Design, of course, is an iterative process. But the design process using BIM is greatly enhanced and many benefits are realized because all the data for a bridge are found in a single location. Conflicts between objects in the model

A BIM model of a precast, prestressed concrete inverted-tee beam. This model is fully populated with all reinforcement and embedments (plates, handling hardware, sleeves). With all data contained within a single model, fabrication drawings, concrete quantities, and component weight can be generated efficiently and accurately. All Figures: Eriksson Technologies.







Partial elevation of a complex, densely reinforced precast concrete tower. With reinforcement, embedded handling hardware, and connections, the detailing of total-precast concrete structures can be challenging using conventional means. However, BIM was used from start to finish on this project to deliver it virtually error free.

Elevation of a single, fully populated precast concrete panel of the tower (partial elevation view shown in the left figure). During erection, BIM is used to ensure that reinforcing bars extending from the bottom of the panel slide precisely into the grout sleeves in the panel below (not shown).

can be detected early and quickly, and can be efficiently fixed. Contrast this with a conventional design workflow, where a problem might not be noticed until the bridge is under construction. The cost of fixing a problem in virtual space where, for example, two objects occupy the same position (referred to as a clash) is trivial. However, the cost of fixing a clash at the jobsite can be extremely high. As we all know, with field problems there is not only the obvious cost of labor and materials but also the time expended determining a solution and the resulting impact on the overall project schedule.

With design centered on a 3-D model of a bridge, new doors open to radically improve safety, accuracy, and quality of design. Technology is available to create two-way connectivity between engineering design software and BIM models. There are no longer two separate models—one for design and one for a "drawing"—just one 3-D model. Software can do a lot of the heavy lifting associated with creating and finalizing a design. Tools can be created to assist the designer with bridge geometry, component selection, component sizing, reinforcement design, the layout of reinforcement, and other detailing tasks. Traditionally, this process has been called automated design, but in recent years has been eclipsed by artificial intelligence, which is broader in scope and deeper in complexity. There seem to be no hard limits on the ability of computer hardware and software to perform every aspect of the design. The human/cyber team can take projects to completion faster, more accurately, and more cost effectively than ever before.

Fabrication support is one aspect of designing and detailing total-precast concrete commercial structures where BIM has proven to be invaluable. The structural components for these types of structures are precast, prestressed concrete components fabricated in plants. Detailed fabrication drawings and bills of materials are required, and accuracy is an all-important concern. There is simply no room for error. Humans can perform this work, but it is tedious and has potential for error if done manually. This is the type of work at which computers excel.

BIM tools can generate detailed, ready-to-fabricate piece drawings and bills of materials for all the structural components and connections in a project. Projects delivered in this manner typically yield efficiency gains exceeding 25%, which translates to a minimum 25% reduction in total labor costs to design and fully detail a project. BIM technologies have also been applied to bridge projects that use precast, prestressed concrete components, such as bridge girders, deck panels, pier caps, piers, piles, and other precast concrete product types.

For more than two decades, government entities such as the Federal Highway Administration and the National Cooperative Highway Research Program have made substantial investments that have laid the groundwork for implementing BIM in transportation. Most of this work has been to develop formats and open standards for data interchange. That's certainly a good start, but BIM now needs to be implemented industrywide. Going forward, we see a good parallel between BIM implementation in the commercial and bridge worlds. At Eriksson, we are dedicating serious resources to BIM delivery for bridges. Others are too. We expect that this will increase the pace of BIM adoption for bridges at an increasing rate going forward.