Building Information Modeling in Bridge Design and Construction

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Building information modeling (BIM) has transformed how infrastructure projects are designed and delivered. In vertical construction, adoption of BIM has been rapid, providing architects, engineers, and owners with a shared digital environment to manage projects. In the bridge sector, adoption has been slower, but the use of BIM is steadily gaining momentum. BIM is not merely a visualization tool; it is a working platform that influences every stage of project delivery: planning, design, fabrication, construction, and eventual handover to owners for operation and maintenance. Owners, engineers, and contractors are tasked with developing and converting a digital model into a physical structure while balancing priorities related to time, cost, quality, and safety. This article explores BIM's impact on bridge design and construction through the lens of Kiewit as an engineer and contractor, focusing on benefits, challenges, and the road ahead.

Geographically correct three-dimensional (3-D) models are useful for visualization and planning. Figure: Kiewit/Trimble/Autodesk/Bentley Systems/Google Earth.

Integrated Building Information Modeling

At Kiewit, integrated delivery is more than a project strategy—it is how we operate. The appropriate use of BIM will depend on the project delivery type. On design-build (DB) and progressive design-build (PDB) bridge projects, our design and construction teams work side by side from project pursuit through execution, providing real-time constructability insights that improve design decisions, reduce rework, and drive more reliable outcomes in the field. This collaborative model allows us to optimize construction sequences and material selections, and align engineering strategies early, thereby maximizing value for clients. Because we control critical aspects of the scope by self-performing processes such as formwork, reinforcement, concrete, and other aspects of construction, we can translate digital BIM models into execution plans, with cost and schedule certainty built in from the start.

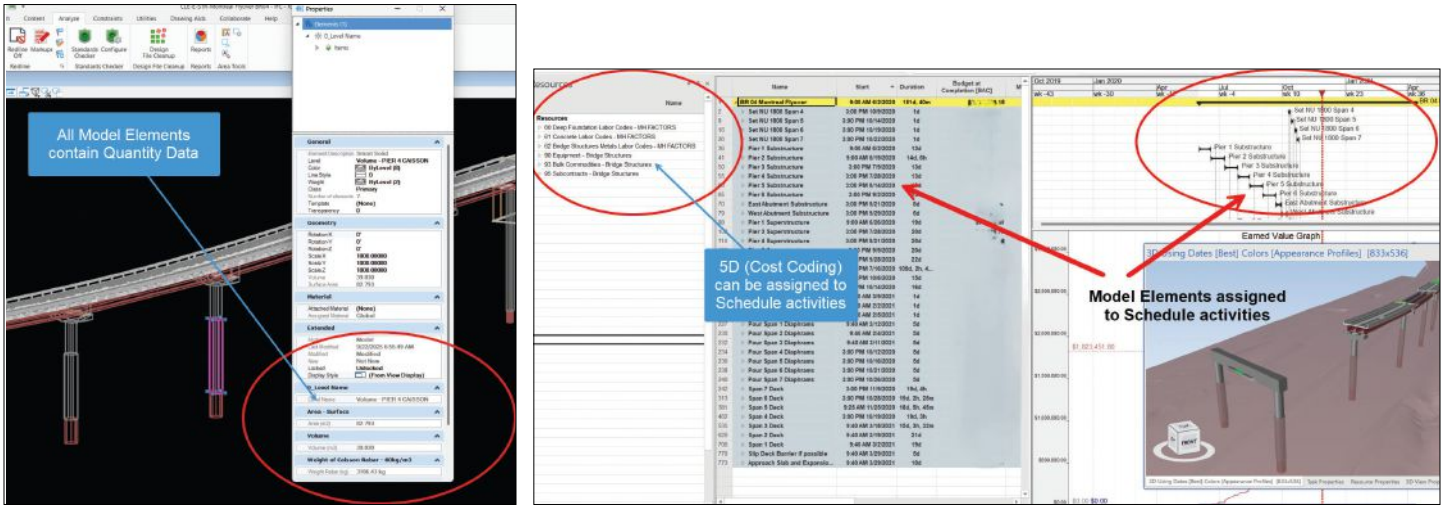
In construction manager at risk and construction manager/general contractor projects, BIM is most effective when it is used as a collaborative, decision-making tool from early design through construction.

In design-bid-build (DBB) projects, contractors have very limited involvement during the design stage. BIM models in DBB projects can balance the need for adequate details for bidding with flexibility for contractor innovation. However, one concern on DBB projects is BIM compatibility with contractor software; it is important to ensure that BIM models can be effectively used and shared in construction.

BIM Benefits

The following are key benefits of BIM in bridge projects:

- Safety planning: Safety is a top priority in bridge construction, especially when projects occur over waterways or live traffic. BIM supports safety planning by allowing contractors to simulate construction activities and identify hazards before work begins. By virtually performing crane lifts, girder placements, or temporary works, contractors can develop safer sequences and train crews more effectively.
- Constructability reviews: One of BIM's most immediate benefits is



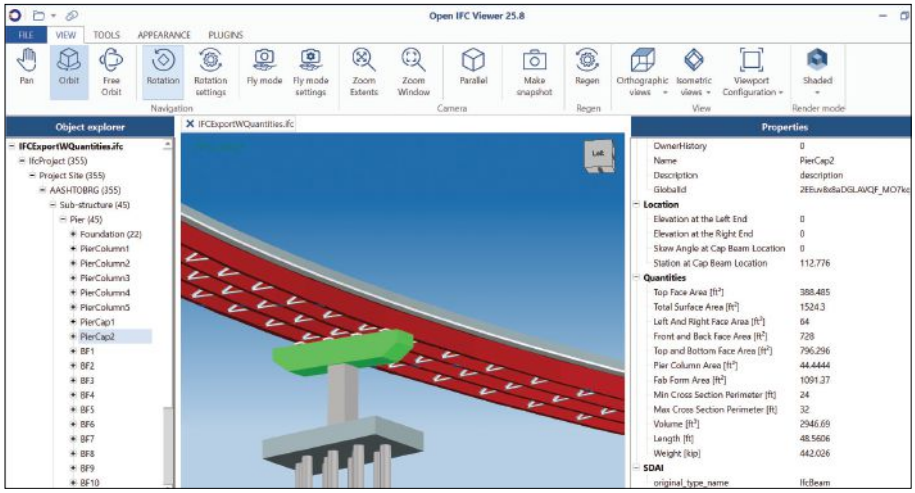
Example of a five-dimensional cost estimation. Figure: Kiewit/Bentley Systems.

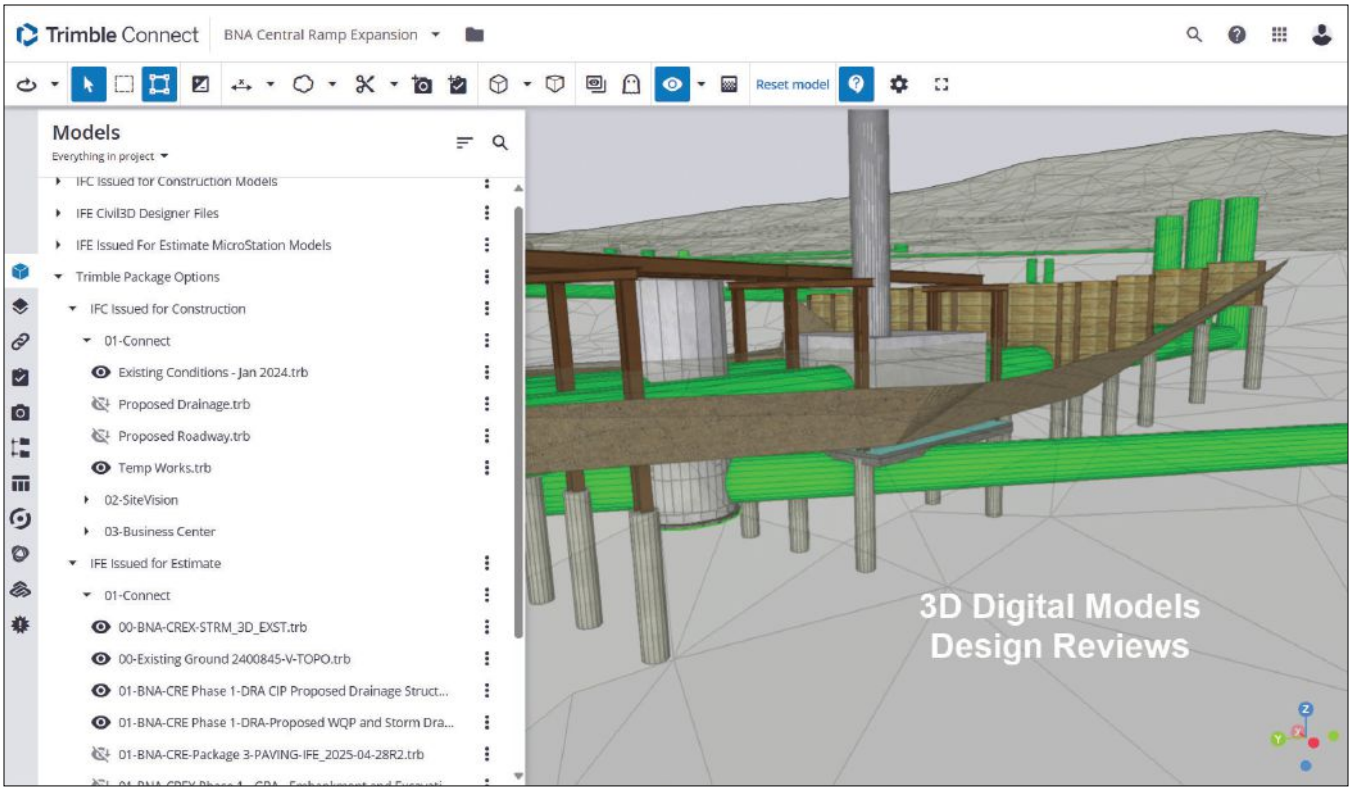
Linking three-dimensional models (upper left) to construction timelines can help with scheduling, construction staging, and the like. Figure: Kiewit/Bentley Systems.

the ability to assess constructability before construction begins. Bridges often feature complex geometries, multiple spans, skewed alignments, and varying foundation conditions. BIM allows engineers and contractors to detect clashes during the design phase. Early identification of conflicts reduces costly rework, change orders, and schedule delays.

- Four-dimensional (4-D) scheduling: BIM enhances scheduling by linking three-dimensional (3-D) models to construction timelines, creating what is known as 4-D BIM. For contractors, BIM can simulate construction staging, traffic detours, crane operations, temporary works, and equipment placement.
- Five-dimensional (5-D) cost estimation: Accurate cost estimation is central to a contractor's role. BIM enables quantity takeoffs directly from the digital model, improving the accuracy of estimates and reducing the risk of underestimation or double counting. With 5-D BIM, where cost is tied to the model, contractors can update cost estimates in real time as designs change. This feature is particularly valuable in DB projects, where rapid decision-making is essential to maintaining budget control.
- Collaboration and communication: Contractors often face communication gaps with designers and owners, especially on large and complex bridge projects. BIM's centralized digital model fosters transparency. Instead of relying solely on two-dimensional (2-D) drawings, all stakeholders can view and interact with the same 3-D model. For contractors, this use of BIM reduces misunderstandings, accelerates approvals, and supports smoother coordination with subcontractors.

Bridge model using the Industry Foundation Classes (IFC) standard. Figure: Kiewit/OpenBrIM/Open IFC Viewer.





Digital model reviews allow engineers and contractors to detect clashes during the design phase, which can reduce costly rework, change orders, and schedule delays. Figure: Kiewit/Trimble.

BIM Challenges and Limitations

While BIM offers clear benefits, the industry also faces significant barriers to effective adoption, including the following:

- Software interoperability: Designers, fabricators, and contractors often use different software platforms. Converting models between formats can lead to data loss, errors, or misalignment of geometry. A lack of interoperability forces some contractors to remodel portions of the design, reducing efficiency. To address interoperability concerns, the BIM for Bridge initiative at Kiewit has been focused on delivering bridge models in the Industry Foundation Classes (IFC) format, which is an open, global standard (ISO 16739[1]). See the Concrete Bridge Technology article, "BIM for Bridges and Structures Pooled-Fund Program," in the Fall 2024 issue of *ASPIRE*® for details on IFC.
- Investment costs: To use BIM, contractors must invest in software licenses, powerful hardware, and training programs. For smaller contractors, these costs may outweigh the perceived benefits, producing gaps in BIM adoption across the industry.
- Workforce resistance: Transitioning from traditional 2-D drawings to digital models requires a cultural shift. Sometimes, even highly experienced field personnel, owners, and design staff will resist adopting new technologies that are unfamiliar to them. We must dedicate time and resources to training and transforming management's view.
- Contractual and legal uncertainties: When BIM models are used, contractors should be cautioned to draft contract agreements carefully to ensure that they are not inadvertently assuming liability for design errors or deficiencies contained within the BIM models provided.
- Insufficient guidance regarding application of BIM models: Bridge models can be extremely large and complex. Such models are often difficult for contractors to use due to a lack of clear guidance on the level of development/detail or the level of information needs. This lack of guidance leads to uncertainty around the intended use, comprehensiveness, and accuracy of the models.

Conclusion

From Kiewit's perspective, BIM in bridge design and construction is both a valuable tool and a challenging commitment. Its benefits in constructability reviews, scheduling, cost estimation, safety, field planning, construction management, and collaboration are undeniable. However, owners, engineers, and contractors must also contend with software interoperability, high investment costs, cultural resistance, legal uncertainties, and data management issues. Despite these challenges, the trajectory of BIM in the infrastructure sector is clear: BIM is becoming an indispensable part of modern bridge delivery. For owners, engineers, and contractors, embracing BIM is not optional—it is the pathway to more efficient, safer, and more cost-effective projects. The bridge industry must continue refining standards, training, and contracts to ensure that BIM achieves its full potential in transforming bridge design and construction.

Reference

1. International Organization for Standardization (ISO). 2024. *Industry Foundation Classes (IFC) for Data Sharing in the Construction and Facility Management Industries*. ISO 16739-1:2024. Geneva, Switzerland: ISO.