The Digital Twin Evolution

Ask the Experts: Digital Twin Technology for Bridge Design, Construction, and Beyond

by Monica Schultes

This article explores the burgeoning world of digital twins and how they could revolutionize the transportation infrastructure industry. It delves into defining this technology and its potential effect on planning, design, and construction of concrete bridges.

Digital twin technology can create a virtual "as-built" replica of a physical object such as an actual bridge. In addition to the benefits this technology provides during design and construction, owners can monitor their valuable asset throughout its life cycle and can predict maintenance needs or improve future designs.

Although the concept of a digital twin has been around since 2002, it has only recently become cost effective to implement, thanks to the internet of things. A digital twin requires three parts: the physical structure, the virtual model, and the connection between the two. It is the continuous connection between the structure and model that distinguishes digital twin technology from building information modeling (BIM).

We asked experts from ALLPLAN Infrastructure, Bentley Systems, and Eriksson Software to discuss how digital twin technology will shape the industry and how digital twins of bridges are making the transition from idea to reality. Responses have been edited for length and clarity.

Q What is your definition of "digital twin"?

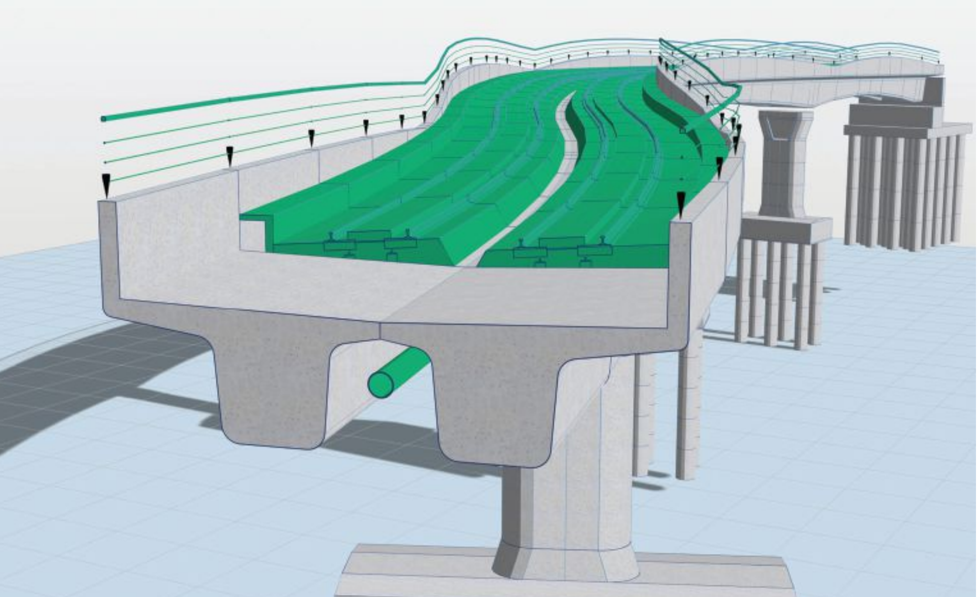
A **ALLPLAN:** We like to refer to the digital twin as a digital replica of construction that helps us to better understand the future. During the design phase, the digital twin simulates how the structure will look and feel. During construction, it monitors the schedule and budget in real time. Finally, through the operation phase, the digital twin monitors how the bridge is performing and anticipates any maintenance.

BENTLEY: The definition we like to use is that a digital twin is a digital representation of a physical asset or system that is integrated with engineering information that allows us to understand and model its performance. A digital twin combines data from continuous surveys, photogrammetry, lidar [light detection and ranging], and sensors. It tracks changes along a timeline, allowing owners to view the digital representation of the asset and the real-world conditions over time. A 3-D [three-dimensional] model is like a snapshot, but the digital twin is like the living, breathing representation of the bridge. It provides the ability to see information beyond the design and construction stages.

Are digital twins a natural evolution from BIM?

ERIKSSON: The digital twin is an extension of BIM but goes further by accommodating more detailed information and with a broader scope. We are changing the way things are done in the design environment. Instead of separate processes for design and drafting, the BIM modeler works in concert with the structural engineer to design and detail a structure and its component parts. They analyze and detail and populate the model. Right now, our work ends at the BIM model. There are still some who print out 2-D drawings and those who are looking to convert to CNC [computer numerical control] machine processes or 3-D printing. BIM is a subset of the twin. You can't have a twin without BIM.

Allplan Bridge and Allplan Bimplus use parametric bridge design and detailing with structural analysis. These platforms store bridge models in an object-based database. Figure: ALLPLAN Deutschland GmbH.



A three-dimensional model is like a snapshot, whereas a digital twin is like a living, breathing representation of a bridge that allows owners to view a replica of their asset in real-world conditions over time. Figure: Bentley Systems.

What is the future of digital twin technology?

BENTLEY: The potential for digital twins is unlimited. Our iTwin Services enable engineering firms to create, visualize, and analyze digital twins of infrastructure projects. Openness will be a prerequisite for delivering digital twins to advance our industry beyond BIM. One future potential for digital twins is with machine learning. Right now, a large amount of data is collected within the digital twin, due to all the changes and connections among information. Machine learning creates an opportunity to see the lessons learned from a portfolio of projects and identify trends and patterns that resulted in mistakes, cost increases, or safety incidents.

ERIKSSON: About 10 years ago we sensed that technology and the communication infrastructure had advanced to the point where widespread interconnectivity among stakeholders in the design process was in sight. BIM was taking hold in our industry. In 2015, we completely redesigned our data framework to enable us to integrate with a fully connected world. We pivoted to staking our future on project delivery via BIM and fully committed to supporting this technology. Our workflow now connects design to a BIM model in a two-way fashion. We developed our technology in the commercial market and are now moving that technology to the bridge market. Because of our extensive planning, there will be no loss of data integrity or fidelity in this transition.

Are there project examples?

BENTLEY: We worked with Foth Infrastructure & Environment to establish a 3-D model as a digital twin, with data flowing to and from the model, as field personnel identified and resolved potential issues on site. The digital twin enabled stakeholder review and buy-in, ensuring that the project was well communicated to the community. Beyond construction, the engineering data contained in the digital twin will provide value to future operations. New York State DOT [Department of Transportation] is taking advantage of technology and moving to model-based design and digital twins. They utilized OpenRoads and OpenBridge to solicit bids in their first-ever model-based contracting project: Route 20. Using digital twins enabled digital review that, compared with traditional print and scan methodology, allowed contractors to access data from the 3-D model on their tablets and easily get elevations.

What are the biggest challenges facing adoption of this technology?

ALLPLAN: 2-D drawing-based methods demonstrate just how error-prone these processes can be, but they are a fundamental part of engineering culture. BIM makes the most sense when the models are used by everyone and thus presupposes that all organizations involved are willing to optimize their processes together. It is a huge challenge to transform an entire industry, especially as paper drawings are still a robust way to get information to a site where sun, rain, mud, thieves, and missing internet connectivity are just some of the challenges for the users of mobile devices.

ERIKSSON: The biggest challenges to adopting this new technology are the lack of software, awareness, and training, as well as the change in traditional methods and workflows. Another hurdle is handling the massive amount of data generated from multiple sources during the bridge design and construction phases.

What are the biggest rewards to stakeholders?

ALLPLAN: The biggest reward to stakeholders is that digitalization through BIM improves quality and saves time and money. Those gains are realized through improved communication and optimized data management during the asset's life cycle. But it is not that simple. We always talk about the technology itself. But it

EDITOR'S NOTE

ASPIRE® *was introduced to the concept of digital twinning in a presentation by David H. Parker at the Structural Health Monitoring Subcommittee (AKT40[3]) meeting during the 2021 Transportation Research Board Annual Meeting. The presentation discussed the digital twinning concept and how it could be used for bridges. The FIU Pedestrian Bridge collapse was used as an example to highlight that the concepts of digital twinning could have been used to provide diagnostic measurements that could have been useful for identifying the structural issues prior to the collapse.*

This article is a brief introduction to digital twinning, and a second article, which will include perspectives from David Parker, is planned to further explore the application of the concept to bridges and how engineering judgment is essential to evaluate conditions and changes when implementing digital twin technology.

An unmanned aerial vehicle (drone) captured high-resolution images that were used to create a reality mesh linked to a digital twin for the restoration of the James J. Hill Stone Arch Bridge project in Minneapolis, Minn. Software from Bentley Systems was used to create the digital twin. Photo: Bentley Systems.

is not only the technology that makes things happen. A very important aspect is the human factor. Within the design process of any structure, many different experts are involved. The number of people involved and the necessity for their collaboration rises with the complexity and scale of the project. The technology is important, because if certain workflows are not established, then there is no collaboration. The platform we have established supports the complete design cycle and, due to our open BIM approach, the exchange of data is streamlined.

ERIKSSON: While it is a huge undertaking, for twin technology to succeed, there have to be immediate benefits to the stakeholders. Efforts to date have fallen short because there needs to be a 20% savings to the design engineer to have the incentive to drive it forward. With Eriksson Sync technology, we are seeing a 25% reduction of the labor for design and detailing of precast concrete, and once you can meet that threshold, the benefits outweigh the learning curve. The success on commercial projects has proven that it [the technology] does help reduce costs and increase accuracy—we have seen a near elimination of errors. Communication is more seamless and real time and unambiguous with the Sync system. Those benefits could also be realized on bridge projects.

How do you think this will transform the industry?

ERIKSSON: Digital twin technology could transform the industry with better collaboration, improved accuracy, better data integrity (it never goes out to paper and then gets scanned back in), error reduction, broader and deeper knowledge about the structure, better record keeping and record accessibility, accelerated fabrication, and improved construction schedules—better results for all stakeholders.

ALLPLAN: Bridges extensively fitted with sensors could facilitate a reliability-optimized maintenance management of bridges. But it is still the construction process where knowledge-based design systems can help to plan and build ever better bridges that realize savings in time and budget.

Conclusion

Digital twin technology is charting a path to reduce design costs, increase accuracy, and improve communication. However, there are several challenges to widespread adoption. Digital twin technology requires time and skilled resources. Because it is so new to the industry, many companies do not yet have this expertise, which leads to the next challenge: money. The initial investment may take several years to recoup. The corporate culture of the industry is slow to adopt new technology, and digital twins are no different. Lastly, lowest-cost project delivery and the fragmented organization of the industry create more obstacles.

Digital twin technology has a lot to offer and now that the technology exists, it will grow and adapt and ultimately change the industry.

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