Bridge design is no simple matter. While traditional 3D modeling software is useful for buildings, these structures don’t present the same challenges that bridge design does. Jalpesh Patel, Senior Technical Consultant with Allplan explains why: “Buildings are mainly linear, vertical structures with minimal to no obstruction. Bridges, on the other hand, are non-linear, horizontal structures that must weave through obstacles, existing structures, and multiple right-of-way restrictions. Therefore, accurately modeling bridges to be constructed in the real world requires software that can adapt to this non-linear geometry.”

When managing the unique challenges posed by bridge design, parametric modeling shines.

PARAMETRIC MODELING

The term parametric modeling derives from the word parameter, defined as a value that helps describe an entire system. When applied to bridge design, this means that certain parameters are set, and the design is then calculated based on those values.

This is a far more advanced and efficient method of 3D building information modeling (BIM) than simply creating a model from geometry and then analyzing it to see if it will serve the intended purpose. Rather, parametric modeling uses equations to develop a design that will meet the specified needs. However, this is a fairly new technology and the available software tends to be difficult to use.

Patel says, “There are a handful of 3D modeling software programs that provide parametric modeling capabilities, but they all do it through a process called ‘visual scripting.’ This is similar to coding and is a fairly complicated workflow for bridge engineers unlikely to have coding experience, so it’s difficult for bridge design firms to manage it.”

A BETTER WAY

Fortunately, there’s a better alternative. “With Allplan Bridge, we made this cutting-edge workflow more user-friendly for design engineers,” Patel explains. “It offers a familiar-looking user interface, hiding the visual scripting in the background of the software. Within the application, design engineers work with two-dimensional cross-sections and tables to produce 3D parametric models in a way that’s very similar to the 2D CAD sketches and spreadsheets they’re already familiar with.” However, Allplan Bridge does the heavy lifting for them in the background.

With parametric modeling, if a change becomes necessary during the design phase, it does not require that the model be scrapped and reworked. Instead, the software
calculates how the modification will affect the entire design and makes the appropriate changes to the model itself, ensuring that the pre-established parameters are preserved.

“This technique allows 3D modeling of complex and varied geometric cross sections while still providing full user control,” says Patel. “This method of modeling for horizontal structures like bridges is distinct from the traditional linear variation modeling capabilities provided by the majority of 3D modeling solutions adopted from the vertical building industry.”

Because bridges possess horizontal and vertical curvature that allows for smooth flow of traffic and obstacle avoidance, modeling them accurately requires software that can adapt itself well to nonlinear geometry.

ECONOMY OF DESIGN
One of the benefits of parametric modeling is that it yields information that makes for a highly viable yet optimally economical design.

First, it provides a real-world geometric representation of the final structure, increasing the accuracy of the analysis associated with load, wind, weather, expansion and contraction, and so on. This reduces uncertainty, allowing the designer to provide a safe and stable design that does not incorporate unnecessary features or materials. The software also enables the engineer to develop many detailed bridge concepts for a given project in a short period of time, which increases the potential for finding the most cost-effective design for the job. This puts the design firm using parametric modeling at a distinct advantage.

Over time, Allplan Bridge assembles a library of cross sections from completed projects to improve future designs. These projects can also be analyzed, and that data applied to new opportunities to derive more realistic quantities, clash detection, and cost estimates, facilitating even more realistic and competitive bids on upcoming bridge projects.

STAGING BENEFITS
Allplan Bridge is not just a design tool, however. Its interface offers excellent benefits during staging operations as well.

Patel says, “One engineering team usually designs the bridge in its entirety, while another team stages it for building from the ground up, one segment at a time. This requires a different analysis model for each stage. However, with Allplan Bridge, the full bridge analysis and all the different staging modes can be performed from a single model.”

Because the software incorporates a sophisticated workflow feature, the initial design team finalizes the design and passes it on seamlessly to the construction staging analysis group who will divide the bridge into segments and make recommendations to the contractor about how to construct it. The software is able to take these inputs and provide a detailed staging analysis about moments, shear, deflection, creep and shrinkage, temperature, and so on, for each stage of construction. This information allows the staging team to conclude whether the structure will be stable at
Parametric models represent "digital twins" of real-world structures. The models’ utility extends beyond construction and staging to maintenance. Sensors can be placed in the bridge that are integrated with the virtual BIM model, providing real-time, online access to the state of the structure from anywhere in the world.

Patel adds, “Designers are very intrigued by this young software’s capability and precision compared to more traditional BIM software.” Given its powerful capabilities and benefits, parametric modeling is poised for tremendous growth in the future.

In addition, any potential constructability issues can be addressed before work begins to reduce the risk of cost overruns or delays in schedule. And by staying on schedule, worker overtime is minimized, which also prevents accidents.

STAKEHOLDER TRANSPARENCY
Part of the elegance of Allplan Bridge involves its sharing of a detailed, three-dimensional visual with all stakeholders in the process. Patel says, “This can be shared on the Bimplus cloud platform through Allplan Engineering for collaboration purposes. On Bimplus, the owners can monitor project progress; civil engineers can perform clash detection against utilities and other obstructions; and contractors can get measurements and quantities. Everyone can communicate through an organized task system built right into the software.”

There’s no guesswork involved with changes made to the design either. Everyone can see the design and any modifications made to it as the project progresses. Further, Allplan Bridge incorporates a fourth dimension into its database—that of time. As the design evolves and tasks are mapped out, scheduled, and completed, these are logged so that no information is lost, even for projects that have a lengthy design span.

THE FUTURE OF PARAMETRIC MODELING
“The true value that parametric modeling brings to BIM is offering designers the ability to model virtual structures exactly as they will be constructed in the real world,” Patel says. “It resolves all the uncertainties before construction begins so that there is no guesswork about what the final product will be.”