Bridges and Tunnels eBook

e-book title: **Connecting the Future: Smart Solutions for Bridge and Tunnel Infrastructure**

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BRIDGES AND TUNNELS TODAY

Bridges and tunnels are the backbone of our connected world. They carry millions of people daily, move billions of dollars in goods, and connect communities across rivers, mountains, and urban landscapes. These engineering marvels don’t just move traffic - they drive economic growth, enable trade, and shape how societies develop.

But our bridge and tunnel infrastructure faces unprecedented pressure. Many structures built 50+ years ago now handle traffic loads they were never designed for. Climate change brings new challenges with extreme weather, flooding, and temperature swings that stress aging materials. Urban growth demands more capacity while budgets shrink, and skilled workers become harder to find.

The traditional approach of building in silos - where road design, structural engineering, and geotechnical work happen separately - creates gaps that lead to costly surprises, rework, and delays. Data gets lost between phases. Design intent disappears. Construction teams work with outdated information.

There’s a better way. By connecting every phase of bridge and tunnel projects in a unified digital environment, you can build smarter, faster, and more cost-effectively while creating infrastructure that adapts to future needs.

MAIN DRIVERS FOR CHANGE

**Five major challenges driving the need for smarter bridge and tunnel infrastructure**

**Aging Infrastructure Under Rising Demand** - Most bridges were built over 50 years ago and are functionally obsolete. They’re handling more traffic, heavier loads, and new requirements for safety, accessibility, and resilience. In the US alone, over 220,000 bridges need major work. Meanwhile, tunnel systems face similar aging issues with outdated ventilation, lighting, and safety systems struggling to meet modern standards.

**Disconnected Design and Construction** - Bridge and tunnel projects still rely on disconnected workflows where geometry gets rebuilt multiple times, design intent is lost, and data doesn’t flow between phases. Road alignments, structural spans, and foundation models often exist in separate systems, creating misalignment that leads to costly rework, schedule delays, and budget overruns during construction.

**Complex Subsurface Uncertainty** - Tunnel projects frequently encounter unexpected ground conditions that derail budgets and schedules. Limited visibility into soil conditions, water tables, and geological risks means construction teams face costly surprises. Even bridge foundations can hit unexpected subsurface challenges that require expensive design changes and construction modifications.

**Skills Shortages and Capacity Gaps** - The infrastructure industry faces a growing talent shortage just when bridge and tunnel needs are highest. Experienced engineers are retiring faster than new talent joins the field. Teams are stretched thin across multiple projects, making it crucial to work as efficiently as possible with automated workflows and intelligent design tools.

**Climate Resilience and Budget Pressure** - New bridges and tunnels must withstand extreme weather, flooding, seismic events, and temperature variations while meeting sustainability goals. These requirements increase design complexity and construction costs. At the same time, budgets are tight and accountability for carbon emissions and lifecycle performance is higher than ever.

**TRANSFORM YOUR BRIDGE AND TUNNEL CHALLENGES INTO OPPORTUNITIES WITH BENTLEY’S CONNECTED INFRASTRUCTURE PLATFORM**

**Build Resilient Infrastructure Faster** - Bentley’s integrated modeling environment lets you design bridges and tunnels together with road corridors in a single shared model. This eliminates geometry rebuilding and preserves design intent from concept through construction. You can rapidly iterate on complex curved spans, variable tunnel profiles, and challenging foundation conditions while ensuring everything stays coordinated.

**Connect Disciplines Across the Lifecycle** - Our platform breaks down silos between road, bridge, tunnel, and rail teams. Soil profiles inform both bridge foundations and tunnel linings. Rail alignments feed directly into bridge and tunnel models. Construction simulation spans all elements without data conversion. This integration reduces errors, speeds delivery, and improves project outcomes.

**Minimize Subsurface Risk** - OpenGround integrates borehole logs, geological surveys, and ground investigation data directly into your design models. Geotechnical and structural teams work from the same subsurface understanding, allowing you to anticipate challenges, optimize foundation designs, and reduce construction surprises that blow budgets and schedules.

**Maximize Team Productivity** - Automated design workflows, AI-driven condition assessment, and generative design capabilities help smaller teams accomplish more. Smart components accelerate routine tasks while powerful analysis tools handle complex scenarios. This lets your experienced engineers focus on high-value design decisions instead of repetitive modeling work.

**Ensure Long-term Performance** - Digital twins connect design models with real-world performance data throughout the asset lifecycle. Inspection data flows back into the original design model, enabling predictive maintenance, condition forecasting, and data-driven renewal strategies. This extends asset life while reducing long-term costs and improving safety.

**SOLUTIONS MADE SPECIFICALLY FOR BRIDGES AND TUNNELS - ABOVE AND BELOW GROUND**

Put these opportunities into action with Bentley’s solutions designed for the unique challenges of bridge and tunnel infrastructure - from initial concept through decades of operation.

**Design** - Create integrated bridge and tunnel designs that coordinate with road and rail corridors from a single source of truth

**Construction** - Deliver complex projects safely and on schedule with 4D sequencing and real-time progress tracking

**Operations** - Monitor performance and manage maintenance with intelligent asset management and condition assessment

**Lifecycle Management** - Extend asset life and optimize performance with predictive analytics and digital twins

Design inspiration – Something with the lifecycle loop

A diagram of a company

AI-generated content may be incorrect.

A close-up of a white square with text

AI-generated content may be incorrect.

A diagram of a project

AI-generated content may be incorrect.

**DESIGN SOLUTIONS MADE FOR BRIDGE AND TUNNEL INFRASTRUCTURE**

With Bentley’s comprehensive bridge and tunnel design platform, you can create coordinated designs that integrate seamlessly with transportation corridors. Our geometry-driven approach handles complex curved alignments, variable cross-sections, and challenging subsurface conditions while keeping all disciplines synchronized throughout the design process.

**Accelerate Complex Geometry** - Rapidly model curved bridge spans, complex tunnel profiles, and variable girder depths with parametric design tools that automatically update connected elements when changes are made

**Integrate Subsurface Intelligence** - Bring geotechnical data directly into structural models so foundation designs, tunnel support systems, and earth retention work from accurate ground conditions

**Ensure Code Compliance** - Automated code checking and analysis ensure designs meet requirements from the start, reducing review cycles and late-stage changes

**Solutions**

* Survey data management
* Geotechnical design and analysis
* Structural design and analysis
* Bridge design and analysis
* Tunnel design and analysis
* Drainage and hydraulic design
* Building design and constructability review
* Carbon analysis

**DESIGN SOLUTIONS IN ACTION**

**HS2 uses an integrated design environment for Europe’s most complex infrastructure corridor**

**The project** - High-Speed Rail 2 (HS2) is the UK’s new high-speed railway connecting London, Birmingham, Manchester, and Leeds. The project includes over 50 bridges, 10 major tunnels, and complex rail-road-tunnel intersections across one of Europe’s most challenging infrastructure corridors.

**The challenges** - HS2’s scale and complexity demanded unprecedented coordination between bridge, tunnel, and rail teams. The project crosses dense urban areas, historic landscapes, and challenging geology while meeting strict environmental and safety requirements. Traditional disconnected workflows would have created massive coordination problems across the 150+ mile route.

**The results**

* **Seamless integration** - OpenRail, OpenTunnel, and OpenBridge worked in a single connected environment, preserving design continuity across all disciplines
* **Reduced risk** - Coordinated models eliminated clashes between rail alignments, bridge structures, and tunnel sections before construction
* **Faster delivery** - Integrated workflows reduced design iteration time and enabled rapid assessment of alignment changes

“The ability to work across rail, bridge, and tunnel disciplines in one environment was game-changing for a project of HS2’s complexity. We maintained design intent throughout while coordinating across dozens of teams.”

**CONSTRUCTION SOLUTIONS MADE FOR BRIDGE AND TUNNEL INFRASTRUCTURE**

Bridge and tunnel construction demands precise sequencing, safety coordination, and real-time progress tracking. Bentley’s 4D construction modeling and project delivery platform helps you plan complex builds virtually first, coordinate across multiple contractors, and track progress in real-time to keep projects on schedule and within budget.

**Benefits**

**Plan Complex Sequences** - Model bridge deck pours, tunnel segment installation, and utility coordination in 4D to identify conflicts before they happen on-site

**Coordinate Multiple Trades** - Keep structural, mechanical, electrical, and civil teams aligned with shared access to current project information and progress status

**Track Progress in Real-Time** - Monitor construction progress against planned schedules with visual dashboards that highlight delays before they impact critical path activities

**Solutions**

* Construction modeling
* Construction progress tracking
* Construction inspection and forms management
* Construction execution
* Excavation analysis

CONSTRUCTION SOLUTIONS IN ACTION

**Ferrovial delivers complex urban bridge replacement with 4D modeling**

**The project** - A major bridge replacement in a dense urban area required demolishing the existing structure and building a new bridge while maintaining traffic flow on the highway below. The project included complex utility relocations, staged construction, and strict safety requirements for work above active roadways.

**The challenges** - The construction sequence had to minimize traffic disruption while ensuring worker safety above busy highways. Multiple contractors needed coordination for demolition, utility work, and new construction. Any delays would have significant economic impact on the region’s transportation network.

**The results**

**Improved coordination** - 4D modeling enabled all teams to visualize the complete construction sequence, identifying potential conflicts before mobilization

**Reduced disruption** - Optimized sequencing minimized highway lane closures and shortened the overall construction timeline

**Enhanced safety** - Virtual planning identified safety hazards and enabled better protection systems for work above traffic

“Having the entire project modeled in 3D with the digital twin increased communication efficiency by leaps and bounds. Construction segment directors no longer had to work from finalized 2D plans - they could see and understand reality.” - Carlos Gonzalez, Ferrovial Construction

**OPERATIONS SOLUTIONS MADE FOR BRIDGE AND TUNNEL INFRASTRUCTURE**

Managing bridge and tunnel assets requires continuous monitoring, predictive maintenance, and rapid response to changing conditions. Bentley’s AI-powered inspection and asset analytics platform helps you shift from reactive maintenance to predictive management, extending asset life while improving safety and reducing costs.

**Benefits**

**Predict Maintenance Needs** - AI analysis of inspection data identifies deterioration patterns and predicts when maintenance will be needed, allowing you to plan and budget more effectively

**Accelerate Condition Assessment** - Automated analysis of drone imagery, sensor data, and visual inspections quickly identifies issues across large bridge and tunnel portfolios

**Optimize Resource Allocation** - Data-driven insights help prioritize maintenance spending on assets with the highest risk and greatest impact on network performance

**Solutions**

* Linear condition monitoring
* Inspection systems
* Maintenance management systems
* Asset performance monitoring
* Routing and permitting systems

**OPERATIONS SOLUTIONS IN ACTION**

**Tecne Systra-Sws transforms tunnel assessment and rehabilitation with digital implementation**

**The project** - A comprehensive digital transformation of tunnel assessment and rehabilitation processes across multiple tunnel systems in Italy. The project aimed to modernize inspection procedures, improve condition monitoring, and optimize maintenance scheduling for aging tunnel infrastructure.

**The challenges** - Traditional manual inspections were time-consuming, inconsistent, and often missed developing problems. Paper-based reporting created delays in addressing critical issues. The aging tunnel network required more frequent monitoring but budget constraints limited inspection resources.

**The results**

* 851 work hours saved\* through automated processes and digital workflows
* 25% improvement\* in modeling and design efficiency
* 21.5% faster\* project deliverables through integrated workflows
* 30% improvement\* in survey interpretation and verification accuracy
* 30% reduction\* in clash detection time during coordination

“The digital approach transformed how we assess and maintain our tunnel assets. We can now identify issues earlier and respond more effectively while using our resources more efficiently”.

**BUILD WHAT’S NEXT**

**Connecting the Future: Smart Solutions for Bridge and Tunnel Infrastructure**

The challenges facing bridge and tunnel infrastructure today are significant, but they create opportunities for smarter, more connected approaches to design, construction, and operations. With Bentley’s integrated platform, you can transform how you deliver infrastructure projects while building assets that adapt to future needs.

Our solutions connect every phase of bridge and tunnel projects - from initial concept through decades of operation. By breaking down silos between disciplines and enabling data to flow throughout the asset lifecycle, you can reduce risk, accelerate delivery, and create more resilient infrastructure.

Whether you’re designing complex bridge-tunnel-rail intersections, constructing in challenging urban environments, or managing aging tunnel networks, Bentley provides the tools you need to succeed in today’s demanding infrastructure environment.

The future belongs to an infrastructure that’s not just built to last but built to adapt. Connect with us to see how we can help you build what’s next.

**Ready to transform your bridge and tunnel projects?**

Explore our solutions at