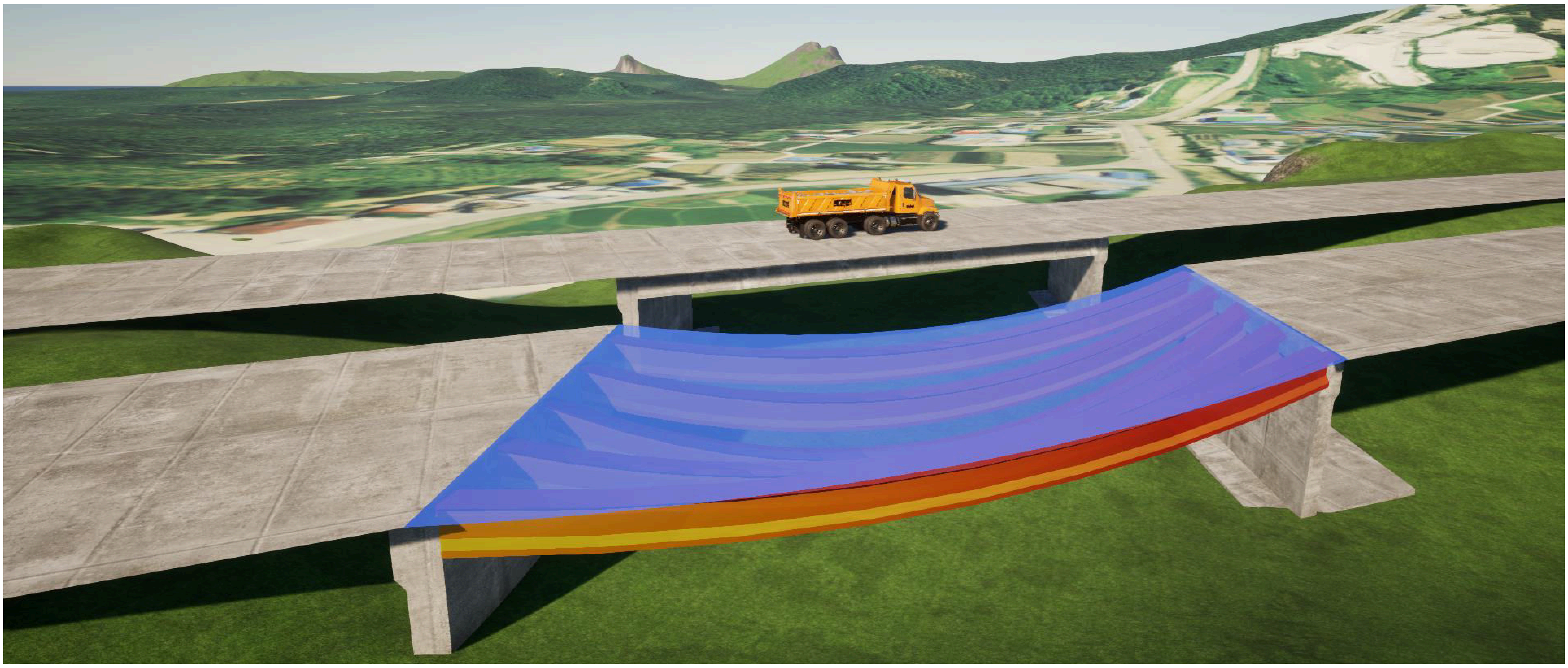


Project summary

Organization:
Smart Prefab Structures Lab

Solution:
Bridges and tunnels

Location:
Gangneung, Gangwon, South Korea

Project playbook:
OpenBridge®

Chung-Ang University Lab develops AI-based digital twin to enable automated, intelligent bridge condition assessments

OpenBridge reduces model calibration time by over 90% and engineering costs by 70%

Project overview

South Korea has many aging bridges, no standard regulations for conducting accurate load testing on bridges, and a limited maintenance budget.

The lab initiated a project to develop an AI-based, digital twin system to support intelligent bridge condition assessments and maintenance.

They selected OpenBridge as the core simulation engine for their digital twin system based on its precise modeling capabilities, automation features, and interoperability.

ROI

Compared to traditional manual calibration, OpenBridge helped the lab achieve a fully automated process that reduced model update time by over 90%.

The digital twin system reduces modeling and engineering costs by 70%, while lowering the need for repeated on-site testing, minimizing carbon emissions and resource use.

Optimizing bridge serviceability assessment and maintenance

During the 1960s and 1970s, South Korea experienced a period of unprecedented economic growth marked by rapid industrial expansion and infrastructure development, including construction of many bridges. Now, over 50 years later, many of these bridges are aging and reaching or exceeding their designed lifespans, creating public safety concerns and a huge economic burden on the country to assess them and take measures to ensure their structural integrity. With no standardized regulations for conducting accurate load testing on existing bridges, the country needs a cost-effective and quick solution to assess their structural health and determine appropriate remediation works.

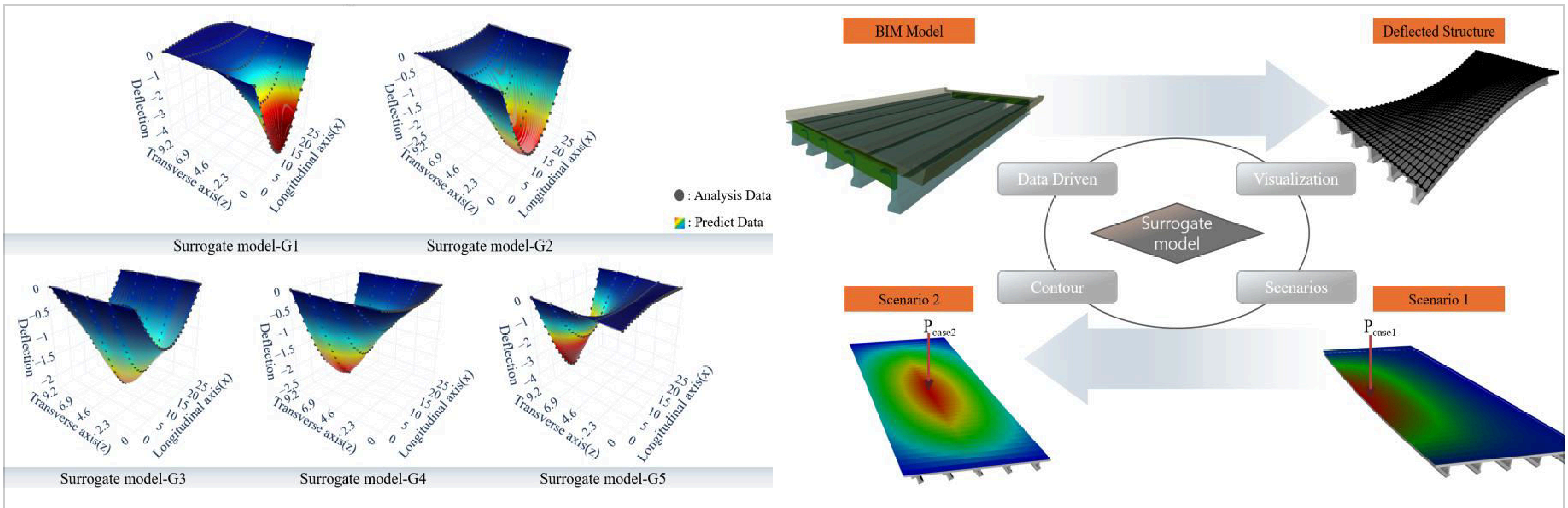
Focusing on advancing digital infrastructure management, Smart Prefab Structures Lab at Chung-Ang University led an initiative to develop a digital twin system for real-time serviceability assessments of aging prestressed concrete (PSC) bridges. "With aging bridges increasing rapidly, and maintenance budgets remaining limited, this project aims to develop a cost-effective optimization system that supports intelligent decision-making in bridge maintenance," explained Jae Wook Park, researcher at Chung-Ang University's Smart Prefab Structures Lab.

The project addresses a critical gap by enabling precise and automated condition assessments through the application of AI and digital twin technology to optimize bridge lifecycle maintenance and management.

Manual workflows and data complexity

"Traditional inspection and analysis methods are time consuming and costly," said Park. Therefore, the team sought to develop a digital twin system that allows engineers to evaluate structural behavior without repeating finite element model (FEM) analysis or field testing, promoting efficient resource allocation using an advanced digital maintenance framework. However, they faced automation, technology integration, and data analysis challenges, affecting model accuracy and validation.

Initially, they relied on manual parameter adjustments to calibrate the bridge models and general structural analysis tools to perform load testing. However, this approach was slow, labor-intensive, and lacked automation, making it ineffective for real-time applications or integration with machine learning algorithms. "It was also ineffective in addressing growing demands for efficient serviceability of aging bridges, especially in the absence of standardized load testing regulations," added Park.



The Smart Prefab Structures Lab selected OpenBridge as the core simulation engine for their digital twin system.

> **"[The project] demonstrates how AI, when combined with robust simulation tools like OpenBridge, can redefine infrastructure decision-making in the era of digital transformation.**
>
> *— Jae Wook Park, Researcher at the Smart Prefab Structures Lab at Chung-Ang University*

The lab realized that they needed an open, interoperable, bridge-specific modeling and simulation application that supported automation and integration with external AI-based workflows.

Leveraging AI-based workflows in OpenBridge

To address the limitations of their prior workflows, the lab adopted OpenBridge as the core simulation engine for developing an AI-based digital twin system. "OpenBridge was selected for its precise bridge-specific modeling capabilities, openness to automation, and compatibility with external optimization algorithms," said Park. Their digital twin system was structured into three distinct stages. First, the team collected data and defined the parameters to be optimized in the FEM. They performed site inspections, core sampling, and load testing. Then, they used an AI-based optimization algorithm and OpenBridge to minimize the error between simulated and measured responses and automate the model updates. Lastly, they used simulation data from the updated FEM to train and develop a surrogate model to predict deflections under arbitrary loads, as well as embedded this surrogate model into the digital twin platform, allowing integration with real-time sensor data for a serviceability assessment.

When live bridge sensor responses are input into the digital twin system, the surrogate model can simulate expected deflection under the corresponding load. If the predicted deflection matches the actual sensor response, the system validates the bridge condition as functional. However, when a sensor response deviates significantly from the surrogate model prediction, the bridge condition is interpreted as abnormal, and the system automatically flags it for structural safety inspection. Working in this unified digital twin environment enables engineers, inspectors, and asset managers to access and visualize 3D bridge performance and collaborate on corrective action plans. "The breakthrough of this project lies in the integration of Bentley's OpenBridge with AI optimization and predictive modeling, transforming a traditionally static FEM into a dynamic, intelligent digital twin," clarified Park

Digital twin provides smart, cost-efficient, and scalable bridge management system

"Our solution establishes a scalable digital maintenance framework that addresses the lack of loading standards while enabling smarter, more efficient bridge asset management," said Park. By using OpenBridge and integrating AI-based optimization workflows, the lab achieved a fully automated FEM update process that shortened modeling time by over 90%, improved model accuracy, and reduced engineering costs by 70%. Working in a unified digital twin platform reduced on-site inspections by an estimated 30%, minimizing emissions related to site travel and promoting environmental sustainability when performing bridge assessments. The digital process eliminates the need for unnecessary load testing and ensures timely safety inspections.

Through real-time condition assessments, early detection of abnormal response, and optimized decision-making and planning, the Lab's digital twin system supports proactive maintenance strategies and public safety, while providing scalable benefits, especially valuable in regions with increasing numbers of aging bridges and no standardized load test regulations. The surrogate model can be reused across similar bridge types without retraining. By combining analytical precision with visual interaction, the digital twin supports smart lifecycle bridge infrastructure management. "Ultimately, the project demonstrates how combining Bentley's OpenBridge with AI optimization and BIM technologies can produce a next-generation digital maintenance platform—reducing time, cost, and risk, while enabling data-driven decisions based on both simulation and real-world measurements," concluded Park.

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