Bridge Information Modelling To Cover A Complete Set Of Processes

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Bridge information modelling goes beyond traditional bridge design by fostering data reuse in downstream processes.

The Sutong Bridge in China's Jiangsu province can claim the world's longest cable-stayed span -- 1,088 meters -- and the longest cables. China's Highway Planning and Design Institute (HPDI) designed the bridge in cooperation with a consortium of local and international consultants.

The team faced extraordinary challenges due to environmental factors and operational demands. For instance, the Sutong Bridge can withstand earthquakes and a marine monsoon subtropical climate characterized by heavy rains, fog, typhoons, and tornados. In addition, it can resist the impact of a 50,000-ton ship. Complex hydrology and deep bedrock problems were solved by pile caps resting on bored piles sunk into sandy soils.

To accomplish all this, the Sutong Bridge had to undergo sophisticated 4D analyses of the structure's dynamic behaviour under many configurations and conditions over time. To address large displacements, for example, designers would analyze geometric nonlinearities, from preliminary design through detailed design. Multiple investigations would examine the impacts of heavy winds in all conditions of operation. A best-design girder cross section would result from bearing capacity and wind loading analyses, and the team would need to optimize distribution of cable forces, minimize stay cable vibrations, and determine stressing for proper cable tension at each stage.

Permission granted for companies based outside of China to contribute to special tasks enabled HPDI to deploy Bentley RM Bridge software, chosen for its proven versatility demonstrated through extensive use on Hong Kong's Stonecutters Bridge, the first cable-stayed bridge to surpass the previously accepted limit of 1,000 meters for a main cable-stayed span.

Sutong Bridge, China

Large bridges like China's Sutong Bridge are the most complex and expensive of any transportation asset. Ultimately, every process -- from planning to operation and decommissioning -- participates in the creation and use of an information definition of the bridge. Individual bridge practices evolve and blend as bridge information modelling (BrIM) provides leeway for sweeping process improvements.

BrIM benefits the entire bridge lifecycle, project selection through rehabilitation, resulting in the development of new best practices. A 3D model of the bridge can serve as a window into the vast bridge information asset. Because the cornerstone of BrIM is data reuse, there is an emphasis on purpose-ready information delivery. And with more flexible access to information about the bridge, organizations can begin to optimize business processes that cross the bridge lifecycle.

Bridge model data is developed in earnest during planning, design, and construction. The close cooperation required of stakeholders during these phases depends not

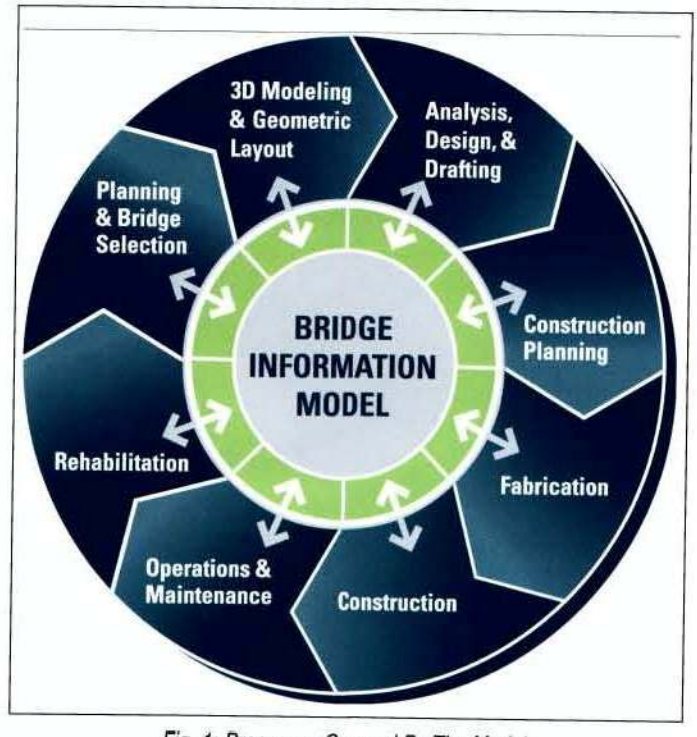

Fig. 1: Processes Covered By The Model

only on data reuse but also smooth interoperability between software/data systems. The information that is developed during these phases informs downstream processes and is essential to bridge lifecycle sustainability.

BrIM enables the transportation industry to efficiently and effectively address the challenges of new and ageing bridges and deliver sustainable, long-lasting infrastructure. "Growing demand for new bridges in developing economies and ageing bridges in developed economies are behind burgeoning workloads and mounting backlogs for bridge engineers around the world," explained Bentley CEO Greg Bentley. "In fact, according to the U.S. Department of Transportation, in the United States alone more than a quarter of the nation's almost 600,000 bridges are deficient and more than $65 billion could be invested immediately in a cost-beneficial way to replace or otherwise address existing bridge deficiencies."

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Bentley's strategic initiative to deliver BrIM technology for the entire bridge lifecycle has spawned a business unit called Bentley BrIM, which will provide broad access to newly acquired advanced bridge products and will integrate these and other related Bentley products to provide interoperable, data-managed bridge solutions for planning, design, engineering, analysis, fabrication, construction, maintenance, and rehabilitation.

The executive tasked with driving the firm's new Bentley BrIM business unit, Senior Vice President Gabe Norona, stated, "Bentley's BrIM initiative will focus on new approaches to bridge project delivery and bridge sustainability. By closing the gaps in traditional bridge lifecycle processes and facilitating the flow of digital information between the various stages, BrIM will enable bridge designers, builders, and owner-operators to easily share a common bridge information model. This will help optimize design decisions and lead to process innovation, largely through information reuse."

An amazing feat of design and engineering itself, the Sutong Bridge has ushered in an era in which multiple bridge designers from around the world are provided with more flexible access to information throughout the bridge lifecycle that has, in effect, raised the standard by which bridge innovation is currently measured.

Stonecutters Bridge, Hong Kong

Stonecutters Bridge will be a distinctive landmark on the Hong Kong skyline as its towers approach a height of 298 meters and their slender decks cantilever from each side over the Rambler Channel. When completed in 2009, the bridge will provide service to travelers on their way to and from Hong Kong's international airport as well as alleviate congestion on the existing road network and provide enhanced links to the container terminals.

Fig. 2: Stonecutters Bridge, Hong Kong

Fig. 3: Stonecutters Bridge Under Construction

The bridge concept design was procured through an international design competition to choose a bridge form from those submitted by world-class engineers and architects. Careful planning, testing, and calculation through the design and construction phases were required to ensure safety and adequacy of the structure through a 120-year design life.

A span of more than 1 km was required to provide unobstructed shipping access under the bridge, making Stonecutters Bridge the world's second longest spanning cable-stayed structure. This pushed the limits of existing cable-stayed bridge technology, and the project required extensive design studies. Located in an area prone to typhoons, the bridge also had to withstand strong winds through all stages of construction. Sophisticated computational methods as well as numerous wind tunnel tests were required to fully understand the behaviour and effects of the wind loading.

A cable-stayed bridge of this magnitude requires a thorough understanding of the structure's behaviour in all conditions. This was gained through extensive monitoring, model testing, and analysis. Bentley RM Bridge provided wind-buffeting analysis and construction-stage modelling. Control of the bridge geometry during erection and checks to verify the contractor's methodology were essential. The new erection control module in Bentley RM Bridge was extensively used to allow for accurate non-linear analysis of the large deformations that can occur during construction of relatively flexible structures. Bentley software easily handled the complex analyses required.

Software Components

Bentley RM Bridge

Structural engineering, design, and analysis software used worldwide for large and medium span bridges, including cable-stayed bridges. With its wide range of international design codes, RM is unmatched in its support of highly intensive, specialized engineering for bridges of all types.

Bentley LEAP Bridge

A parametric, integrated design and analysis solution for pre-cast, cast-in-place, reinforced, and post-tensioned concrete -- an industry standard in place at 38 U.S. state DOTs, the Federal Highway Administration, city and county agencies, and engineering consultancies.

Bentley BridgeModeler And Bentley LARS

Companion products for bridge load-rating, analysis, and analytical modelling for existing and planned bridges offering conformance with the latest AASHTO bridge design specifications, and interface to the AASHTO BRIDGEWare database.

Bentley SUPERLOAD

For advanced oversize/overweight vehicle permitting and routing that takes full account of bridge load-rating and analysis data.

For further details, website: www.bentley.com