Role of BIM in Infrastructure Seismic Retrofits

By Terry D. Bennett, LS, LPF, MRICS, LEED AP

Many of the challenges and opportunities that define the early years of the 21st century are most visible in cities, where a growing proportion of the world's population now lives. The complexities of cities today mean that the demands on infrastructure change and expand constantly. City managers have a responsibility to ensure that their physical and technological attributes support the changing needs of their citizens – and they must do so under all types of pressures.

These pressures range from the strains of rapid urbanization to addressing the potential for loss of life and economic destruction from the approximately 18 major earthquakes (7.0 magnitude and above) that occur worldwide each year. The recent earthquakes in Chile, Haiti and Japan attest to the stark differences between structures that were designed or retrofitted to handle large earthquakes and those that were not. While much is reported about buildings, the infrastructure component of cities must be taken into account as well.

We need new holistic perspectives on cities. In order to develop infrastructure strategically, economically, sustainably and with added seismic resiliency, the right tools are required. Ideally, these tools can help users to transition to a more integrated approach and assessment, where they can visualize, simulate and analyze infrastructure designs long before construction to meet the ever-changing demands. Some of these tools exist today.

Critical Components

A city's basic physical systems – including roads and utilities – are essential to the health of its economy. Currently, there is a worldwide focus on the need for stronger, safer infrastructure.

Transportation systems (including highways, railroads, airports and harbors) and utilities (such as gas, electric, water and wastewater) represent critical components. Any disruption to these systems causes an immediate ripple effect. In the event of an emergency, transportation systems in particular are vital. They facilitate mobility for search and rescue and medical teams to get the injured to hospitals; provide access to repair and restore critical utilities, such as power and water; and enable movement of provisions, including food and water. During a natural disaster such as an earthquake, it is imperative that transportation systems remain operational or be restored as soon as possible.

Past events have shown that earthquake damage to highway components (e.g., bridges, roadways, tunnels and retaining walls) can severely disrupt traffic flow and negatively impact the short- and long-term economy of a region, as well as hinder post-earthquake emergency response and recovery activities.

Seismic Retrofitting: The Role of Building Information Modeling

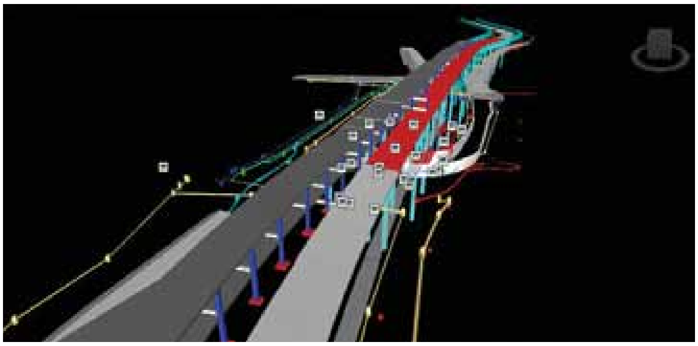
In the past, seismic retrofit was done in order to achieve a specific public safety objective, but engineering solutions were often limited by economic and political considerations. However, with the development of Performance-Based Earthquake Engineering (PBEE), performance-level objectives are now recognized. Although there is no such thing as an earthquake-proof infrastructure, through appropriate visualization, simulations and analysis procedures, the effects of future infrastructure challenges – including seismic events – can be mitigated.

This is where Building Information Modeling (BIM) can play an important role. BIM is an intelligent model–based process for gaining greater insight to accelerate better planning, design, construction and management of infrastructure systems, economically and with less environmental impact. BIM design tools provide a new approach, and can help rehabilitate and retrofit aging transportation and urban infrastructure projects. BIM helps users create highly detailed 3D structural models of roads, railways, bridge tunnels and utilities to enable public, government, engineering, construction and business communities to better understand the task holistically and plan alternatives. In addition, the BIM process can help identify, diagnose and even predict problems that city infrastructures might experience in the future by simulating such seismic events and their impacts.

BIM can aid designers and contractors by enabling modeling, analysis and collaboration at any point in the project lifecycle, including existing conditions under stress. Once the future design parameters are known, a BIM process can aid in the creation of alternatives that address them while helping to identify the most economical and time-efficient approach to construction.

Two excellent examples of these concepts can be seen in online videos related to the Alaskan Way Viaduct project in Seattle. To view these videos, visit the STRUCTURE website – **www.STRUCTUREmag.org/relatedvideo.aspx**.

Terry D. Bennett, LS, LPF, MRICS, LEED AP is the senior industry program manager for civil engineering and planning at Autodesk. He is responsible for setting the company's future vision and strategy for technology serving the planning, surveying and civil engineering industries, as well as cultivating and sustaining the firm's relationships with strategic industry leaders and associations.



Alaskan Way Viaduct Seattle. BIM enables designers to address one of the biggest challenges, to develop a series of design alternatives that are very different from each other, yet all seismically safe and fiscally responsible replacement structures for the viaduct. Courtesy of Parsons Brinkerhoff.

Presidio Parkway Project Road Seismic Retrofit. Preliminary design of new tunnels and entrance to the golden gate bridge. Courtesy of Parsons Brinkerhoff.

BIM: Getting Started

To transition from an existing paper or 2D process to BIM, especially for infrastructure retrofits, it is best to start at the beginning. Most of our infrastructure today has outdated or nonexistent plans, and few have complete and up-to-date existing condition surveys. This lack of baseline information makes it difficult to predict future performance throughout the life of existing infrastructure structural assets, especially when a retrofit project involves evaluating and comparing proposals from various companies to determine which has the best chance for seismic resiliency.

Traditionally, the solution was laboriously to create drawings in 2D form and use them as the basis for an engineered seismic analysis. While these drawings include all of the needed information for submission to the local authority and are used by the contractor for installation or by the inspector for conformance review, creating as-builts by hand is not efficient given the volume of infrastructure that needs to be addressed for seismic retrofits worldwide, let alone the myriad of inputs required today for project approval.

Fortunately, new technologies make this once overwhelming prospect more manageable. Over the past few years, terrestrial and mobile laser scanning as well as aerial Light Detection and Ranging (LIDAR) have facilitated fast, accurate and precise data capture of existing infrastructure assets. The point clouds produced from these scans can be combined with 3D modeling software and a BIM workflow to create rich hybrid data sources, providing an as-built model of existing infrastructure that enables designers to work within the 3D environment to evaluate design alternatives.

For example, the point cloud that results from capturing road, bridge or other structure geometry and characteristics through laser scanning can be used to create a model for use in a BIM process in order to visualize and simulate the performance, appearance and cost of renovations. This allows a designer to explore design alternatives, associated structural performance analyses, seismic audits, and cost and schedule visualizations, thus enabling better decision-making by project stakeholders. The power to have part of the point cloud turned into a model in the areas of critical design, while leaving the rest unchanged, provides the best of both worlds.

The 3D digital model can include data components that represent infrastructure elements such as materials, weight, loading resistance, and other physical properties that contribute to seismic performance, as well as cost or schedule parameters. With BIM, users can then more accurately analyze and assess the performance of individual components, and evaluate, compare, and rank the environmental and financial impact of proposed renovations for an entire system. With a deeper understanding of the relative performance of the infrastructure portfolio, stakeholders can prioritize an overall infrastructure modernization program, and focus on those projects that have the greatest impact or are of the most critical nature. Traditional methods are time-consuming and often inaccurate, which can lead to unacceptable scheduling delays and budget overages.

Besides helping design and construction professionals retrofit based on accurate existing conditions, the combination of advanced capture technology with the ability to visualize, simulate and analyze in 3D helps provide owners with a tool for the future. Scanning at the completion of the project produces an as-built deliverable for the owner. This base-line can be used in operations and maintenance over time to see if any movement or other degradation takes place by simply scanning again and comparing the two models. This allows detection of issues long before they would be apparent from visual inspection, and can make mitigation more cost effective.

BIM can improve project management, helping save money. It enables the inclusion of the whole community and administrative stakeholders at local, regional and national levels. Any nation's growth and economic prosperity is dependent on the adequacy and resiliency of its transportation and utility infrastructure in times of crisis. Through very detailed 3D visualization, simulation and analysis, BIM helps users to forecast future infrastructure requirements for cities and to address concerns.

Future Infrastructure Design

Laser scanning combined with BIM requires a rethinking of traditional methods, yet there are plenty of success stories. It is clear that the speed, accuracy and efficiency of these tools are turning what was once an unmanageable task into a process that is both more accurate and efficient, and that helps to reduce our impact on the environment while improving the quality of the spaces in which we live and work

The challenges and opportunities that define the early part of the 21st century involve cities and their supporting infrastructures. With advances in technology, BIM now enables engineers working on seismic and other retrofits to balance safety, resiliency and cost requirements. This integrated approach also means that city managers can establish more collaborative solutions to plan for the city's future, and deliver more resilient infrastructure that meets the needs of an ever-changing landscape.▪