Making the Case for Resilient Design

by Evan Reis, U.S. Resiliency Council

My hometown, Half Moon Bay, Calif., is an unassuming and quaint hamlet south of San Francisco. People know it as the center of Prohibition era "rum running" on the northern California coast, and it claims to be the pumpkin capital of the world. Although many tourists and residents cross the Pilarcitos Creek Bridge as they drive or walk to Half Moon Bay's charming downtown, they likely do not comprehend the structure's historical significance. Built in 1900, it was the first reinforced concrete bridge erected in San Mateo County—and a very early attempt at prestressing, too. Functioning continuously for more than 100 years, the bridge remained in operation after the 1906 earthquake and following several flood events in which the creek overflowed its banks. To me, the bridge defines resilience!

Built in 1900, the Pilarcitos Creek Bridge in Half Moon Bay, Calif., was the first reinforced concrete bridge erected in San Mateo County. Photo: Burnell G. West.

Measuring Resilience

When we think of what makes a community resilient after a natural disaster, the measure is how quickly the services that a city provides to its residents (housing, employment, goods and services, emergency care, etc.) can be restored. Three components of the built environment are essential to recovery: the buildings in which these services are provided, the utilities that allow these buildings to function, and the transportation infrastructure that permits people to get to and from places where they live, work, and conduct business.

Transportation infrastructure (roads, bridges, airports, and railways) is often taken for granted. However, when the 2010 and 2011 earthquakes hit Christchurch, New Zealand, residents throughout the earthquake-affected region suffered as transportation routes were shut down because of infrastructure damage. In the United States, we only have to look to the Interstate 35 Mississippi River Bridge collapse in Minneapolis, Minn., in 2007, or bridge collapses caused by flooding and landslides in Cedar Rapids, Iowa, in 2009, and Big Sur, Calif., in 2017, to see that the performance of bridges is an essential link in the chain that allows a community to function during and after a natural or human-caused disaster (see **Fig. 1**).

USRC Mission and Goals

The U.S. Resiliency Council (USRC) was founded in 2011 as a nonprofit organization with the goal of "improving community resilience, one building at a time." Its mission, however, is broader than just looking at building structures. Resiliency must be the focus of every component of community infrastructure, including transportation. As we have seen in disasters within the United States just since Hurricane Katrina, a mere 15 years ago, true sustainability cannot be measured only by our impact on the environment; we must also consider the impact the environment has on us. In other words, resilience is different than and complements green design, and sustainability is about more than just eliminating carbon.

As the USRC has developed its building rating systems for describing the expected impacts of earthquakes, hurricanes, wildfires, and floods on a building, it has used leading engineering and scientific research on performance-based design to quantify performance not only in terms of safety but also in terms of repair costs and recovery time. The latter two metrics allow owners, government agencies, lenders, and insurers to calculate the return on investment of building more resiliently.

The USRC is aware that considerable research on the performance of bridge structures has been done and is ongoing. Quantifying the long-term performance of bridges will help define the benefits of building more resiliently. These benefits can be turned into incentives to cities and builders to use concrete technologies and other means to create durable, high-performing systems.

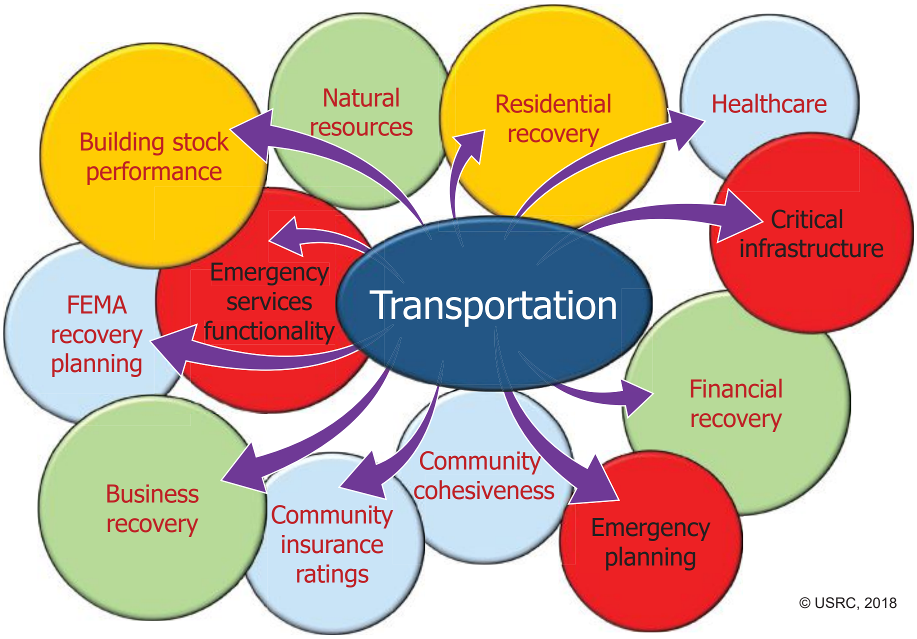

Figure 1. The central importance of transportation in resiliency. Figure: Evan Reis, U.S. Resiliency Council (www.usrc.org).

I worked as a consultant on a project for the renovation of a major freeway corridor in southern California that included the structural risk modeling of more than a dozen overpasses and bridges. My efforts were used by the contractor to obtain proper construction term insurance against the potential for earthquakes or flooding. The evaluation of resilience of the many concrete bridge structures had a direct impact on the amount of insurance that the builder was required to obtain, a cost shared in part by the transportation authority. This was a "concrete" example (forgive the pun) of how the resilience and durability of a specific structural system translated into cost savings.

The USRC encourages the bridge and transportation industries to invest in research that quantifies the performance of bridge structures subject to natural hazards. It is the first necessary step to make the case that using resilient materials such as concrete is a worthwhile investment that more than pays for itself in the short and long term by reducing the social and economic impacts of natural hazards on communities. The USRC would like to expand its rating system to include infrastructure and to make the strongest case for resilience as an essential component of sustainable design. In future articles, I will examine how the detailed process of resilience-based design can be employed by the bridge industry to promote the benefits of precast/prestressed concrete design.

Conclusion

As a structural engineer, I know that the people who work or live in the buildings I design are unlikely to reflect on how the structures are constructed to keep them safe and protect their livelihoods. Bridge engineers also understand that their work, although essential, is not widely appreciated. Most of the folks that visit Half Moon Bay or do their grocery shopping in town and cross the Pilarcitos Creek Bridge probably do not think about the engineers who designed it. And that's okay. But those of us responsible for making sure buildings don't collapse in an earthquake and bridges aren't swept away in a flood must consider the long-term performance of structures and weigh the costs and benefits of resilient design.

EDITOR'S NOTE

See the Perspective article on quantitative assessments of resilience and sustainability in the Spring 2019 Issue of ASPIRE®.

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