Public Works for Public Learning: The Golden Gate Bridge Outdoor Exhibition Project

By Michelle Phillips, David Heil, and Robert Reitherman

Some public works are monumental structures like the Eiffel Tower and the Sydney Harbour Bridge, but most are commonplace, even invisible. Public works exist to provide basic services, but they also present opportunities to engage the public in understanding fundamental concepts of science, technology, engineering, and math (STEM). In this article, we discuss the Golden Gate Bridge Outdoor Exhibition project, which was funded by the U.S. National Science Foundation and opened in San Francisco in 2012.

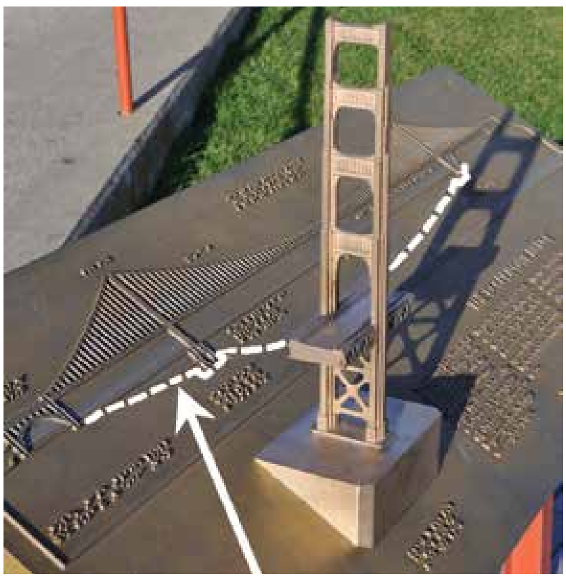
The underlying assumption of the project was that approximately 10 million visitors a year come to the bridge as tourists, and, as written in the funding proposal, "they will come as sightseers, but leave with the experience of having their curiosity piqued by innovative science and engineering exhibits."

DESIGNING THE EXHIBITS

The project was managed by the Consortium of Universities for Research in Earthquake Engineering (CUREE), and exhibits were designed by CUREE and several other organizations, including the Exploratorium in San Francisco and Sciencenter in Ithaca, New York.

The exhibition consists of an innovative set of place-based exhibits installed at the visitor area at the San Francisco end of the Golden Gate Bridge to give visitors insights about the bridge's engineering and construction *(www.goldengate.org/exhibits)*. The project team decided to include exhibits that fit with at least one of five themes:

1. **Emphasizing the "why" behind the "what."** It was important to the designers to go beyond statistics about the completed construction and explain why various engineering decisions were made. For example, a fascinating statistic is that the 4,200-foot (1,280-meter) span set a



This exhibit uses text in Braille and a tactile undersea topography outline (highlighted in this photo with a dashed white line and arrow) to make its message accessible to visitors with and without visual impairments. It explains why the Golden Gate Bridge spanned so far: moving the towers closer together would have meant construction work in deep water. Exhibit design by Bob Reitherman, CUREE, and Lighthouse for the Blind and Visually Impaired. Photo courtesy Golden Gate Bridge, Highway and Transportation District

This exhibit shows three possible heights for the towers of the Golden Gate Bridge. The greater the distance from top of the towers down to the bottom of the sag of the cables, the more efficiently the cables can lift the weight of the deck. The trade-off is that the cost and difficulty of building taller towers would have outweighed that cost savings. Exhibit design by David Fleming, the Exploratorium. Photo courtesy Golden Gate Bridge Highway and Transportation District

world record when the bridge was completed in 1937. One exhibit shows the undersea topography, which reveals that moving the towers closer together would have meant positioning them in deeper water. The extreme difficulty of deep-water construction is underscored by photos of divers in metal diving helmets and air hoses working in a deep-water environment, giving visitors clues about why the engineers designed such a long-span structure.

2. **Explaining an engineer's way of thinking.** Trade-offs and competing criteria are very much a part of civil engineering practice today, as they were in the 1930s when the Golden Gate Bridge was under construction. For example, an exhibit designed by the Exploratorium has three models of the bridge with towers of different heights. Each model has a bridge deck of the same size and weight. Visitors can pull the cables to feel the differences in pulling force (tension) to lift the decks. The tallest towers require the lowest pulling force, so they need only small-diameter steel cables. The shortest towers require the greatest pulling force, and therefore, the thickest cables. Engineers had to balance the cost trade-offs between tower height and cable thickness. The middle-sized towers in the exhibit match the proportions used in the actual bridge. Building taller towers would have been more costly and difficult than making bigger, stronger cables. Building shorter towers would have cost less, but the costs of the corresponding thicker cables and larger concrete anchors would have exceeded those savings.

3. **Including hands-on and discover-it-yourself exhibits.** Many of the exhibits are interactive and

This portion of a tall strut was made identically to one of the original struts on the bridge and then tested in a University of California civil engineering laboratory. Photo courtesy Golden Gate Bridge, Highway and Transportation District

paired with more detailed graphic and contextual information. The typical visitor experience at the bridge includes a strong breeze coming through the Golden Gate Strait; hence the exhibition project addresses how engineers keep the bridge from twisting or moving too much in high winds. In an exhibit designed by Princeton University engineering student Elizabeth Deir, visitors can twist two scale models of the bridge deck to feel the difference in twisting (torsional) stiffness, or resistance, before and after a 1950s wind retrofit project.

4. **Showing engineering artifacts.** One artifact shown is a cutaway of a seismic isolator bearing to show its steel–rubber sandwich construction. The exhibit is located near one of the bridge's approach spans, which are mounted on seismic isolators, providing visitors with a comparison to the actual bridge. The artifact illustrates that civil engineering can be a "high-tech" discipline in which new materials and devices are invented. Another artifact is a replica of a portion of one of the bridge's massive steel struts. The replica strut is noticeably buckled from testing done at a civil engineering laboratory and underscores that engineering involves experimentation, not just computer simulation.

5. **Capitalizing on the site-based aspect of the exhibition.** The exhibit designers wanted to direct visitors' attention to particular parts of the bridge as they stand at an exhibit. For example, a display that conveys the concept of a load path—the way a weight or load is carried by one structural element to another and finally to the ground—uses wording to address visitors directly. The display reads, "Look at the trusses that extend along the length of the bridge" before explaining details about the deck trusses, and "See the 500 vertical lines (steel suspender ropes) across the bridge?" to introduce the role of suspender ropes.

The centerpiece of the outdoor exhibition will be a stainless steel scale model of the bridge, 86 feet (26 meters) long, designed by Princeton University professor Maria Garlock and

Chief designer Sylvester Black and Princeton professor Maria Garlock designed an entire Golden Gate Bridge—every strut, every cable—at a scale of 1:80 (80 times smaller than the actual bridge). This exhibit has not yet been installed. It is shown in its intended "outdoor gallery" with satellite exhibits around it. Rendering by Doron Serban. Image courtesy Golden Gate Bridge, Highway and Transportation District

engineering student Sylvester Black, to tie together the individual exhibits and provide a site map to each one. This feature has been designed but not yet installed.

MANAGING PROJECT CHALLENGES

The outdoor exhibition project faced several challenges. One was the need to collaborate and compromise with the complex array of agencies with jurisdiction at the exhibition site, which is within a historical site controlled by a federal regulatory agency, the U.S. National Park Service (NPS). All the exhibits ideally should be situated in sight of the Golden Gate Bridge, which would require removing part of a historic concrete cannon pit; thus far, the Park Service and California Office of Historic Preservation have not allowed that. Also critical was the relationship with the Golden Gate Parks Conservancy, which has a sole-source arrangement with the NPS to provide various visitor services and improvements in the area around the bridge. After the exhibition project was underway, the conservancy advanced ambitious plans that came with significant funding and their own visitor-serving model, overlapping somewhat with the exhibition.

Another challenge has been the nature of the visitors themselves. People visit science museums with intent. Visitors arrive at the Golden Gate Bridge to see the bridge, walk across it, and take a photo, not to see engineering exhibits. Also, the number of international visitors is quite high, which led the project team to have all the exhibit panel materials translated from English into nine other languages. The translated materials are accessible via the website, and some of the on-site exhibit panels include QR codes for mobile device connections. Expectations have to be modest for how long many visitors will dwell at the exhibits. For example, some visitors only have time to set foot on the bridge, hurry to the restroom or gift shop, and reboard a tour bus.

The harsh environment is also challenging, since the moist, salty air accelerates corrosion; however, use of hot-dip galvanized steel and the proper grades of stainless steel have proven adequate. The exhibits also had to be accessible to people with disabilities, a challenge in an outdoor historical site where making changes to the landscape is not trivial.

And then there is vandalism. A small but significant set of visitors have engaged in "visitor misbehavior," ranging from jungle-gym antics, to the usual graffiti, to late-night vandals with tools and an intent to destroy. Exhibits located farther from the more trafficked pedestrian areas have experienced the most vandalism, and the well-lit areas monitored by security cameras the least.

EVALUATING VISITOR REACTIONS

As part of the summative evaluation, David Heil & Associates conducted a General Visitor Survey. Responses were gathered on-site over a four-week period using a short survey. The more than 460 visitors surveyed were 51% male and 49% female, and the majority were ages 21–50 with the largest percentage being ages 21–30. Most of those surveyed were visiting the Golden Gate Bridge for their first time (67%), and more than half a dozen nationalities were represented.

A high proportion of respondents agreed or

strongly agreed that the outdoor exhibits made their visit to the bridge more enjoyable (84%), increased their understanding of the bridge's history (83%), and increased their understanding of the science (80%) and engineering (83%) behind building and maintaining the bridge. In addition, 69% of surveyed visitors would be interested in seeing more hands-on exhibits about the bridge added to the area, and 60% reported being interested in seeing hands-on exhibits at a public works site near their home town. These data speak to both a strong individual impact and the potential for more public works venues to develop informal education resources and experiences for public audiences.

SURVEYING THE PUBLIC WORKS COMMUNITY

Members of the American Public Works Association (APWA), who include personnel from local, county, state, and federal agencies, as well as private sector

Students take their final steps before reaching the summit of the Sydney Harbour Bridge as they participate in Year 7–8 Science School Excursion Climb. The experience centers on the topics areas of forces, expansion/contraction, and corrosion. Photo courtesy Bridge Climb Sydney

personnel who provide services to these agencies, were surveyed about their awareness of public learning projects. While extensive public-works-for-public-learning activities were uncommon among the 659 surveyed APWA members, 95% still reported using some kind of strategy to connect with their communities. Typical vehicles for public outreach were websites (86%), public hearings (70%), and public newsletters (65%). These members also shared that they were most interested in using educational content posted to their agency's website, interpretive displays at their sites, and public tours to teach their communities about local public works. Yet only 16% of respondents reported that their communication with the public "usually" or "always" shared the science and engineering involved in their work.

Obvious barriers to a public works agency mounting an informal engineering exhibition are cost and expertise. Most public works projects do not include a budget for interpretation, nor do public works staff usually have experience in designing and fabricating interpretive exhibits. APWA members responding to the survey showed an interest in gaining experience in this arena and in getting advice on raising funds to support public exhibits. In response, David Heil & Associates offered a webinar for APWA members on the nature of interpretive exhibitions and other strategies for engaging public audiences.

OTHER PUBLIC WORKS FOR PUBLIC LEARNING

Worldwide, numerous public works tourist destinations provide informal STEM education to their visitors. We give a few examples below:

- **Eiffel Tower,** Paris. The Eiffel Tower hosts over 7.1 million visitors a year and on average has 30,000 visitors per day. Here, the learning opportunity is the engineering of the monument itself. Exhibits explain the tower's design and its use over the decades in aeronautical, radio communication, and other engineering research *(www.toureiffel.paris)*.
- **Hoover Dam,** Colorado River on the Nevada–Arizona border. Hoover Dam hosts 4,000 visitors a day on carefully choreographed and scheduled tours that highlight the dam's engineering *(www.usbr.gov/lc/hooverdam/service)*.
- **Panama Canal.** The massive canal expansion program that began in 2007 and is nearing completion has included one new visitor center and an expansion of another. While viewing the canal, visitors can learn about the canal's history, biodiversity, and functioning *(visitcanaldepanama.com/en)*.

- **Sydney Harbour Bridge,** Australia. Visitors can explore the bridge's history and engineering in a visitor center and get a view from on high by climbing over the top of the arched bridge *(www.bridgeclimb.com).*
- **WaterWorks,** Arizona Falls, Phoenix. This small hydroelectric plant has a public art exhibition space and recreation facility to host local events, including science festivals. Tours focus on sustainability and irrigation *(www.srpnet.com/water/canals/azfalls.aspx).*

Have efforts to use public works for public learning been successful as innovative ways to deliver STEM learning in diverse settings? Yes. Are there special challenges involved? Yes. Are there opportunities to address the challenges and deliver this kind of real-world STEM learning? Absolutely.

Both the engineering community that designs and operates public works and the public that pays for and uses the services of these facilities are largely untapped outreach opportunities or "markets." For science centers, this presents a novel opportunity to look around their communities and identify potentially new partners and sites where STEM topics can be successfully conveyed to new audiences. By combining their expertise and resources, science centers and public works agencies have the opportunity to take public STEM learning to a whole new level. ■

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