Role and Responsibility

Upgrading Highway Bridge Infrastructure

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There is general agreement that the country's infrastructure is in critical condition. With available funding that pales in comparison to the amount needed, engineers working on infrastructure-related projects have a professional obligation to produce high-efficiency projects to ensure maximum impact is obtained from the available funding.

Infrastructure is a very broad term, comprising roads, bridges, tunnels, railroads, stations, airports, seaports, dams, electricity, water and wastewater systems, etc. To analyze the complexity of the problem, consider an area of infrastructure where data is routinely collected and quantified – highway bridges in the U.S.

For years, the American Society of Civil Engineers (ASCE) has been monitoring bridges and providing periodic "report cards" on their condition. The National Bridge Inventory also provides yearly information on the status of our bridges. In 2016, there were 614,400 bridges in the U.S. with total a deck area of 371,500,000 square meters (91,799 acres!). 56,000 of these bridges (9.1%) are classified as *Structurally Deficient*; 84,100 (13.7%) are *Functionally Obsolete*, or a total of 140,100 (22.8%) of all bridges are substandard. By deck area, the percentage is even higher at 26.5%. All these bridges need to be retrofitted, strengthened, or replaced. This is an enormous task requiring a tremendous amount of money, design, and construction effort. At the current pace, a full replacement or retrofitting of the substandard bridges will require 78 years; this is an unacceptably long period. It is essential to design and build *efficient* bridges to maximize the available resources (construction materials, labor, etc.) to meet the demand.

Project efficiency – defined as saving cost and materials while providing a quality product – has always been very important. Today, given the extreme necessity for replacing or strengthening substandard bridges, the responsibility of engineers to design and build efficient, less expensive structures becomes as essential as life-safety requirements. An efficient project optimizes delivery resources, thus allowing for the repair or replacement of other substandard bridges that may have life-safety issues.

All engineers involved in bridge infrastructure renovation, from the design engineer and the construction field engineer to their executive managers, from the control-checking engineers to those responsible for planning and accepting projects, and all engineers advising the transportation agencies in the process should strive to provide high level efficient and economic projects.

When advising different agencies, engineers should be objective, their position based on facts and numbers, and in no way should these engineers be influenced by the preferences or politics of the agencies soliciting the advice.

It is time that agencies allowing substandard projects to be constructed with extraordinary costs (such as the New East Span of the SF-Oakland Bay Bridge built for $6.5 billion over 14 years at four or five times the cost of similar structures) be held accountable.

For decades, the construction industry, and specifically planning departments, have used cost for planning, managing, or evaluating projects. Thus *higher cost* has become a symbol of "better." As a consequence, a transportation agency may spend several trillion dollars and not solve the core problem – an unacceptable number of deficient bridges.

A better criterion should replace measuring achievements in a dollar amount – for example, bridge deck, road, or runway completed per every million dollars spent. This will transfer the emphasis from more expensive to more efficient projects. A more expensive bridge is not necessarily stronger or safer than an efficient, economic bridge built in compliance with the bridge design codes. "The least expensive bridge is the best bridge with all other factors the same" (David P. Billington, *Civil Engineering*, March 1990).

Estimating the efficiency of a bridge structure is complicated because there are no standardized measurements for efficiency. Using dollar cost, steel weight, or concrete per square unit of the project may vary for comparing structures with different spans and configurations. It would help to create a national database of bridges, including cost, steel, and concrete used per unit deck area, with efficiency coefficients (for cost, construction materials, and locality) to evaluate and compare the efficiency level of new projects during their planning, design, and construction phases.

Retrofitting and reinforcing, instead of replacing with entirely new structures, should be considered whenever possible. There are many creative, efficient, and rational methods for retrofitting and reinforcing existing structures being developed by both practitioners and researchers. These new methods may be appropriate to introduce more efficiency into the industry.

Transportation authorities can begin this program by scheduling the replacement or reinforcement of substandard bridges with small spans and multiple repetitive applications (which cover probably 80% or more of all substandard bridges). Design and design-build competitions can provide creative ideas for the efficiency of both routine and long-span bridge projects. DOTs can avoid advancing projects with poor efficiency ratings and should consider design competitions for every complex project with higher costs.

Everyone should do his/her part to achieve better efficiency – politicians and lawmakers may contribute by finding and allocating the necessary funding in the budgets; engineers, builders, and administrators may contribute by using both proven and new technology to design and build efficient structures, thereby achieving faster infrastructure recovery.

It is vital to encourage and award highly efficient structures, while inefficiency should be discouraged. Professional engineering organizations like the National Council of Structural Engineers Associations and the American Society of Civil Engineers have advocated and volunteered to serve a more significant role in the promotion of better, more highly efficient projects.

The good news is that there is now a serious call for renovating our infrastructure in general and our highway bridges in particular. This is an excellent opportunity for incorporating innovative structures, using the best solutions for faster, lighter, and more efficient design and construction.▪

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