

MEETING ASCE'S GRAND CHALLENGE: PERFORMANCE-BASED STANDARDS



Seattle is a hotbed of performance-based design. PHOTO: Creative Commons

ASCE's Industry Leaders Council brought together experts and stakeholders for two roundtable discussions during the spring of 2017 to explore shifting standards and processes within civil engineering, specifically as they relate to ASCE's Grand Challenge. The ASCE Grand Challenge aims to reduce infrastructure life-cycle costs by 50 percent by 2025 and foster the optimization of infrastructure for society by focusing on four areas: performance-based standards, life-cycle cost analysis, innovation, and resilience.

The first roundtable, moderated by KCI Technologies's CEO Terry Neimeyer, P.E., ENV SP, BCEE, F.ASCE, focused on performance-based standards. This is a summary of the important points made during that discussion.

Picture a traffic intersection.

Cars are approaching from four directions. The usual rush-hour backups occur. So the local transportation engineers are on the case, looking for ways to make the intersection more efficient and safe.

What do they do?

They turn to the Federal Highway

Administration's *Manual on Uniform Traffic Control Devices*, which—according to George Merritt, Aff.M.ASCE, a highway safety engineer for the FHWA—likely leads to a traffic signal and maybe some additional lanes passing through the intersection.

And that's good. It's tried and true.

But recently, the agency has

begun to encourage a more performance-based approach—one that considers a wider range of factors, including mobility; the potential for, and possible types and frequency of, crashes; and how people experience passing through the intersection, whether on foot, by bike, or in a car. A wider range of considerations means a wider range of possible solutions, too.



Dan Frangopol believes education is central to improved performance-based standards.

PHOTO: Ambience Photography

And within that analysis, engineers also consider the cost to build and maintain the project. As a result of this approach, which the FHWA calls the Intersection Control Evaluation process, Merritt said they are seeing increased use of roundabouts, more diverging diamond interchanges, and fewer intersections with left-turn lanes.

“When we talk about crashes and people getting hurt ... a lot of those crashes are because people are turning in front of oncoming traffic, left-hand turns,” Merritt said.

“We’re seeing those left-hand turn lanes being strategically eliminated from the actual intersection and being relocated upstream. And when you look at it from a cumulative perspective, we are getting a great deal of advantage safety-side, [without] creating any kinds of unacceptable operational deficiencies.

“I would say this is a good example—although a small example—where we’re really

evolving from more of a prescriptive type of approach ... into more of a performance evaluation to help us come up with different solutions.”

ALREADY IN USE

Performance-based concepts are in use now, particularly when it comes to design to withstand wind, seismic events, and fire. Jonathan C. Siu, P.E., S.E., M.ASCE, a principal engineer and building official with the Seattle Department of Construction and Inspections, cited his experience in Seattle successfully applying performance-based design to buildings taller than 240 feet, for which previous codes required a dual frame.

“We were approached ... by an engineer who said, ‘We think we can build a better mousetrap and get rid of these dual frames,’” Siu said. “Particularly, to build the frame on the exterior of the building, which is what the big issue is.”

They brought the idea to a peer review panel, and once it was approved, moved forward with the performance-based design.

This is innovation in action.

“It hasn’t been tested in a real earthquake yet,” Siu said. “But the hope is that we are able to define where the plastic hinges form, control that area, and then, therefore, get better actual performance in a real event.”

Doug Sereno, P.E., ENV SP, D.PE, F.ASCE, the former director of program management for the Port of Long Beach, mentioned two major projects that he oversaw that used performance-

based concepts.

The new Port of Long Beach administration building and the Gerald Desmond Bridge replacement were each budgeted over a 40-year timeframe. Rather than only focus on first costs, the maintenance schedule was built in from the beginning.

The Gerald Desmond Bridge replacement was delivered using design/build and featured a performance-based design. “They said, ‘This is what we want, this is the size ... and it’s got to last 100 years,’” Sereno said.

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Sereno advocates for finding ways to include performance-based considerations on a project-by-project basis.



Don Dusenberry and William Earl talk during the performance-based standards roundtable. PHOTO: Ambience Photography

Seismic, wind, and fire events are ripe for performance-based standards because they present outcomes that are more easily quantifiable than other events. But the concept is at work in other civil engineering disciplines as well. Geotechnical engineering, by its very nature, lends itself to performance-based design.

“Geotechnical [is] frankly, a lot of judgment,” said Don Dusenberry, P.E., SECB, F.SEI, F.ASCE, a consulting principal at Simpson Gumpertz & Heger. “You take some samples from here and there, and you run some tests in a lab, and you say, ‘This means the ground underneath, that I cannot look at, really, has these features and characteristics.’”

It’s assumptive and predictive by necessity.

PERFORMANCE VS. PRESCRIPTIVE

Performance-based standards are an enticing prospect, a way for civil engineers to embrace innovation and creativity and rely on their engineering judgment to

build sustainable infrastructure that can be completed quicker, cost less to maintain, and reliably deliver the intended outcome.

As civil engineers strive to meet ASCE’s Grand Challenge to significantly reduce infrastructure life-cycle cost by 2025, widespread adoption of tools like performance-based standards will be essential.

But how does that approach square with the profession’s traditional—and utterly fundamental—adherence to prescriptive standards?

Listening to Merritt and Robert Nickerson, P.E., F.SEI, M.ASCE, a structural engineer based in Dallas, talk during the roundtable, you might think they’re on opposing sides of the debate.

“I don’t see us ever getting away from prescriptive standards, because you’re going to have to have that in order to have performance success,” Nickerson said.

Merritt, meanwhile, had made the point moments earlier that the idea of simply adhering to standards must be broken if we are going to approach things differently. “We’re trying to make people as uncomfortable as possible because we’re trying to break the culture.”

But make no mistake, the two engineers have the same goal in mind: safe, sustainable infrastructure. The roundtable participants acknowledge that there are many possible paths to achieving that goal.

“These are difficult questions. Engineers are the people who are at least willing to talk about it. Now, that doesn’t mean we always come to a consensus. It’s difficult but it’s also how you spell progress.”

- Jim Harris

CHALLENGES

So, yes, there are challenges.

There are the owners' one-year budgets that don't account for long-term maintenance costs. There are the risk-averse politicians whose election cycles lead them to focus on short-term rather than long-term benefits. There is the perception that a performance-based standard that aims to lower costs must also mean lower quality.

There is also the question of how safe is safe enough?

Jim Harris, P.E., Ph.D., F.SEI, F.ASCE, NAE, a former member of the ASCE Board of Direction with recent experience working on the *ASCE 7-16* design loads standard, said that the two main hurdles to developing a sufficient performance-based standard are defining the objective and measuring the performance.

It becomes a question of semantics, too. Words matter. How do you define 'functional'?

"These are difficult questions," Harris said. "Engineers are the people who are at least willing to talk about it. Now, that doesn't mean we always come to a consensus. It's difficult but it's also how you spell progress."

What exactly does safe mean? Siu said engineers must also consider the audience and whether the code is aimed at the designer or the owner.

"The more general you make [the code], the easier it is," Siu said of performance-based standards. "The difficulty is when it gets

down to the nuts and bolts. ... If you're going to say that 'that beam shall not crack,' then that's going to be really difficult."

And then there is the difficult question of insurance. Is an infrastructure project that adheres to performance-based standards and not a set of strictly prescribed measures toxic to insurers?

It's tough because the insurer focuses on the here and now, said Greg Ketay, senior vice president of compliance and management for Pearl Insurance. Insurers simply can't get into the business of fortune-telling, he said. But the very nature of a performance-based measure is predictive.

"Most, if not all, professional liability policies currently exclude ...guarantees or warranties of future outcomes," Ketay said. "...The engineer that does the initial design says, 'You will do the following maintenance over this period of time.' If that maintenance does or doesn't happen, what's the potential outcome and ultimate liability to that engineer going forward?"

"...So we won't be able to guarantee or warranty, I don't think, the outcome, but we will be able to insure the professional standards," Ketay explained. "We can't insure the unknowns of the future. We can ensure that the engineer follows [the] rules that we [have] in 2017 and [that they] used proper standards and protocols."

All of which brings us back to that word: prescriptive.

"You know, I really think that

THE TAK

DEFINING PERFORMANCE-BASED STANDARDS

Focus on the outcomes that a project must meet, rather than specifying materials and methods

- Drive the design of projects using those outcome-driven standards
- Consider the full life cycle of the project
- Consider performance-based design to be a critical piece—along with resilience, innovation, and life-cycle analysis—of ASCE's Grand Challenge

BENEFITS OF PERFORMANCE-BASED STANDARDS

While cost reduction can be one benefit of moving to performance-based standards, experts say its most significant benefit is optimizing performance. Such an approach:

- Focuses on the project's purpose and its context within the community
- Allows room for innovative design
- Considers the full life cycle of the project, allowing for changes in conditions over time
- Has the potential to reduce project delivery time and long-term costs
- Has the potential to predict a project's behavior over time

WHAT ARE THE BARRIERS?

- The need to prove it first due to the conservative nature of civil engineering
- The insurance and liability challenges of predictive-outcome engineering
- Risk-averse owners and politicians
- Single-year budget cycles
- Policy and legislative impediments

AWAYS

GETTING STARTED WITH PBS: KEYS TO SUCCESS

Currently, performance-based standards is commonly used in seismic and fire-protection design, as well as in the field of geotechnical engineering, whose practitioners deal in uncertainty. To adapt the concept more broadly, roundtable participants offered these tips.

- **THINK BIG:** Consider PBS on large, signature projects in which peer review is already part of the process
- **START SMALL:** Use PBS for a smaller, more routine part of a more extensive project
- **BUILD TRUST** with local regulators before proposing the use of PBS
- **DOCUMENT SUCCESSES** in empirical terms, and share results with the industry
- **FOSTER** increased collaboration between stakeholders, with civil engineers leading the discussion
- **CREATE** a common vision: Develop a primer defining such performance outcomes as safety and operational requirements



we've done this to ourselves," Dusenberry said. "The legal system hasn't done this to us.

"The movement toward very prescriptive codes long precedes our currently litigious bent. I think our profession is naturally conservative because [our concern is] life safety. We have the potential to kill a lot more people than any doctor in the world has.

"So we are very conservative, and I think we've stepped away from responsibilities that civil and structural engineers used to have. We've created a little box for ourselves, and now we have defined those boundaries. We've

to minimize that risk, too. But to look outside of anywhere but our own selves and control for how we've gotten into this situation is, I think, stepping away from our own responsibilities. We're creating our own mess."

SOLUTIONS

But there are ways to mitigate those challenges.

Siu talked about how the peer-review process can help build confidence in a more outcome-driven approach.

Another way to drive that is through data. For example, Merritt pointed out that it's one thing to encourage your

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- Dan Frangopol

put all the rules that we need to follow to stay safe and to protect people, and we've become quite comfortable with this role.

"And sure, you risk getting sued. And you do what you need to do

engineers to consider new solutions; it's another to back up those potential solutions with hard numbers.

"...You've got to justify that through your analysis and



Greg Ketay, of Pearl Insurance, discusses performance-based standards from an insurance perspective. PHOTO: Ambience Photography

documentation,” Merritt said.

Merritt says a handful of states have adopted this new approach. “...And now we’re seeing states that are actually coming up with quantitative evidence to [present] to these people who have problems with things like roundabouts or diverging diamond interchanges and things like that, because they are traditionally uncomfortable for engineers to approve and for the public to accept. We’re able to communicate now because we can ... lay this thing out in terms of metrics.”

Sereno’s successes with the Port of Long Beach were aided by legislative exemptions, allowing for a maintenance budget over 40 years. Political champions are crucial.

And as with anything, education is also a key consideration.

Dan Frangopol, ScD, P.E., F.EMI, F.SEI, Dist.M.ASCE, has taught civil engineering graduate courses on life-cycle costs at the University of Colorado and Lehigh University. He thinks this kind of performance-based approach should be a staple of undergraduate curricula.

“The way the profession is positioned right now, frankly, I think that 99.5 percent of the population wouldn’t know what to do with the true performance-based codes.”

- Don Dusenberry



Don Dusenberry lays out a point during the discussion.
PHOTO: Ambience Photography

“Undergraduate courses are extremely important because students don’t know about the concepts,” Frangopol said.

“They don’t know about the concepts of life cycle. They don’t know about the costs associated with these projects.

“These questions of repair and maintenance [are] an optimization problem in which you have to decide to minimize the life-cycle cost and maximize the performance. Sometimes you have conflicting objectives. It’s important to introduce these ideas into education.”

The need for education extends beyond undergrads, too. The entire industry is still learning about performance-based standards and design.

“It’s an education that we need to undertake across the board, ourselves and our partners, to develop a clear understanding of what we are accomplishing by doing this,” Dusenberry said.

Ultimately the answer to performance versus prescriptive design, as is the case with most questions, likely lies somewhere in between the two poles.

Perhaps it doesn’t need to be an either-or scenario. Perhaps the future of standards is a mix of prescriptive and performance-based approaches.

“You have to have standards that say, ‘This is a good way to do it,’” Harris said.

“On the other hand, you need to have the ability to change,” he added. “Performance objectives are usually stated in relatively nontechnical terms. You start with a broad conversation and then you try to quantify the performance criteria. That’s where the rubber meets the road. What should the quantitative criteria be? That’s a huge civil engineering challenge. But when you get there, you find you can have real innovation.”

ASCE 7-16 includes a section about performance-based opportunities in its opening chapter, though Dusenberry, the past chair of the ASCE 7 Committee, emphasized during the roundtable that the standard remains mostly prescriptive in nature.

“The way the profession is positioned right now, frankly, I think that 99.5 percent of the

population wouldn't know what to do with the true performance-based codes," Dusenberry said.

"We say it [*in ASCE 7-16*], but it's a baby step in the direction of a performance-based code. ... I'm not sure I know what a true performance-based code would look like."

And that's part of the challenge for the industry right now. For a profession that relies on proven methods, it's very difficult to break free from the cycle of not being able to use a method until it is proven, but not being able to prove it until it has been tried.

TRUST AND COLLABORATION

The recurring theme in any path forward with performance-based standards is collaboration. The performance-based success in Seattle that Siu described was fostered by previously established trust between the city and the engineer.

Because establishing the parameters around the intended outcome is so vital to a successful performance-based approach, clear communication at the beginning of the project is crucial.

"Jon's done a good job," said Donald Scott, P.E., S.E., F.SEI, F.ASCE, the vice president and director of engineering at PCS Structural Solutions, of Seattle, in referring to Siu's project example.

"And like he says, he doesn't dictate what it is, but he brings everybody together—the building department, this peer reviewer, and the designer—to have a couple of beginning discussions or beginning meetings, so that we make sure that we're all on the same page of what the performance standards are going to be and what you're looking for."



George Merritt has seen performance-based approaches help at the Federal Highway Administration.

PHOTO: Ambience Photography

And this is where the civil engineer comes in, Sereno said.

Performance-based design relies, in part, on collaboration between designers and financiers. The civil engineer understands best why performance-based design can produce the most effective, sustainable infrastructure for the long term, so the civil engineer should lead that collaborative effort.

"The engineer needs to step up in this conversation and begin to express how this kind of thing can be a benefit in the long run to an agency," Sereno said. "Too often we get caught up in first-cost concerns and meeting constituent expectations of frugality. I think we as the engineers can help educate those who may not be down in the weeds where we are."

"What we have seen for so long is that the engineering group has simply been secondary in this discussion," he continued. "I think it's time to step up and push these concepts more and more. We need to assume the role of trusted adviser by those who have the responsibility for financial interest. We need to establish our role as the trusted adviser who can help explain this and help lead this."



The Port of Long Beach has had success considering long-range outcomes for its projects. PHOTO: Port of Long Beach



THE ROUNDTABLE PARTICIPANTS

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