

Regulatory-ready sustainability or sustainability-ready regulators?

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ABSTRACT

Standards and regulations could stifle innovation needed to advance sustainable principles. Regulations typically are indexed to minimum values of key parameters, and owners are accustomed to paying for the minimum. Consultants and contractors are conditioned to provide low-bid estimates and perform at the lowest level that will meet the standard of care, or not be selected for the work. Innovative ideas tend to be dismissed because they result in costs that exceed low bid, even if they result in lower life-cycle costs, because most “projects” are defined as “design and construction” and treated separately from “operation and maintenance”. Owners reject new ideas because regulators’ review questions delay construction. Both regulatory-ready sustainability and sustainability-ready regulators are needed to advance innovative ideas.

INTRODUCTION

Innovation is needed to advance the principles of sustainable development, but standards for innovative practices have yet to be developed. Just what does balanced economic, environmental, and societal sustainability look like? The triple-bottom line of 21st century business (Elkington, 1997) is a concept that is essentially abstract without context or some examples to connect the dots. Early in the 20th century, economic sustainability largely also meant societal sustainability. By the middle of the 20th century, environmental neglect was recognized to also mean a threat to societal sustainability (World Commission on Environment and Development, 1987). Society’s reaction was legislation for environmental protection for sustainability of Planet Earth.

Innovation is good, and it can happen at a variety of scales. Society developed over eons but with increasing frequency of major advancements, such as fire, stone tools, the wheel, the arch, water power, the bridge, the internal combustion engine, automobiles, vehicle accidents, standardized tire sizes, traffic regulations, bridge failures, improved bridge design, design standards, construction litigation, construction standards, construction inspectors, design standards, and the standard-of-care defense. Many major advancements are omitted from this list, but the point of the list is create a thread from some early advances to some later advances, punctuated by accidents, failures, and standards. Along with the standards come regulations that the standards must be followed, and some ordinances that give agencies authority to enforce the regulation, with staff members who become the regulators.

Among the consequences for not following the regulations are laws that are interpreted and argued before the court by lawyers. Other lawyers defend the constructors and designers who interpret what

was done and argue before the court that the standards were followed. In addition to the constructors and designers who were being defended before the court, so were the owners of the constructed works.

PRINCIPLES OF SUSTAINABILITY – A BRIEF HISTORY

In 2009, the American Society of Civil Engineers (ASCE) established a Committee on Sustainability, which was charged to help ASCE as an organization develop a rating tool for infrastructure that would be somehow similar to the US Green Building Council's LEED® (Leadership in Energy and Environmental Design) program for rating buildings. Why might infrastructure need a rating tool that differs from LEED®? Buildings are under the control of a single entity and building systems can be optimized, whereas entities responsible for infrastructure typically come from multiple departments with different issues, budgets, schedules, and customers, and infrastructure systems must be integrated at community, city, and region levels, making optimization challenging, if not impossible.

ASCE's Committee developed a definition of sustainability which was adopted by ASCE in 2009: "*A set of environmental, economic and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality or availability of natural, economic, and social resources*" (<http://www.asce.org/sustainability>).

ASCE's 2009 definition brought together three concepts: 1) the triple-bottom line (Elkington, 1997), 2) the Brundtland Commission's definition of sustainable development (World Commission on Environment and Development, 1987), and 3) the five capitals (Porritt, 2007). The Brundtland Commission defined "sustainable development" as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs*. Porritt's five capitals were a) financial, b) social, c) human, d) natural, and e) produced.

The principles of sustainability were contextual in discussions about civil engineers striving to comply with them, as stated in ASCE's Code of Ethics (<http://www.asce.org/sustainability>), and remained implied for another seven years. ASCE's Policy 418 was revised in 2016 to define the principles of sustainability as:

1. Do the right project, and
2. Do the project right.

Principle No. 1 is intended to comply with meeting needs with a triple-bottom line approach that may or may not involve a constructed project. Principle No. 2 is "just good engineering", but explained in four parts:

- a. Perform life-cycle assessment,
- b. Use resources wisely,
- c. Plan for resiliency, and
- d. Validate application of principles.

The life-cycle assessment addresses concept to deconstruction (cradle to grave). If operation and maintenance are considered carefully in concept, design, and construction, then "sustainability" sells itself. However, if silos of financing are maintained, then "sustainability" in design looks like a cost without a benefit. Validating application of principles supports the concept that "things that are not measured cannot be managed". The ENVISION™ Rating System was developed by the Institute for Sustainable Infrastructure (ISI) in 2011; ISI is a joint venture of the American Council of Engineering Companies (ACEC), American Public Works Association (APWA), and ASCE.

INNOVATION MAY BE DEAD, BUT CREATIVITY IS NOT

A Major Dam

Actually, innovation is not dead. However, to the author in 1999, it felt like it. I was working on what would become an award-winning roller-compacted concrete dam in one of the quieter parts of a seismically active state; the owner was a water agency. I was responsible for geotechnical site characterization and, in particular, development of the seismic design parameters. I had been on a special professional-society funded research project to learn how to apply a geologically satisfying analytical model to generate realistic three-component seismograms from seismic slip on a finite fault. In the first meeting of the design team for this dam, I stated that I planned to use this state-of-the-art analytical procedure to generate seismograms at multiple places along the 2,200-foot-long centerline of the dam. The seismograms were generated by slip on a finite fault with circular asperities generated by two random number generators – one to distribute the centers of the asperities across the fault plane and the other to assign a radius to each asperity. The two random number generators ran simultaneously until the total rupture area had been satisfied for the seismic moment (i.e., moment magnitude) of the design earthquake. Nearby traces of two active faults had already been delineated, but no historical earthquakes of meaningful magnitude had been recorded on either of these faults, or by seismographs on hard granitic rock like the foundation of the proposed dam. This model was perfect for generating seismograms at different points on the ground surface from the same combination of input parameters, including the seeds of the random number generator. I would be able to calculate vibratory displacements that would allow structural engineers to evaluate shear strains from a single simulated earthquake.

I thought that members of the design team would welcome such a geologically satisfying model with an ability to generate multiple seismograms from the same set of asperities and modeled rupture sequence. And I was right – the engineers on the design team were quite impressed with this approach. The owner, however, may have been impressed, but not favorably. His comment was concise and conclusive: “I don’t want anything innovative to be used on this project.” His reasons were threefold: It would slow down the review process; it would generate questions from the reviewing engineers that the design team would expect to get paid for responding to, and it would delay completion of the project as it had been scheduled. In short, innovation would make the cost of the project go up. He said to me, “How will you respond to a review request to provide three examples of major concrete dam projects in seismically active areas that have been designed with this approach?”

So innovation that seemed quite practical and effective was stifled by the owner because the reviewers would be challenged by something different than what they were accustomed to reviewing.

A Minor Road

A few years after the major dam had received an outstanding project award from ASCE, a severe winter storm caused numerous landslides and erosion gullies on the steep slopes above Los Angeles. Substantial damage occurred to transportation and stormwater infrastructure, as well as residential. In areas of recent wildfire, the damage was much more intense than in one particularly area where an unpaved road was rendered impassible by landslides and erosion. The road was initially constructed in the 1880s to provide horse-and-wagon access to timber resources. The timbered area became the site of a resort hotel that burned and was rebuilt several times over the following 80 years. The land became on which the road and the hotel were located became National or State Forest; the area where the

hotel had been located became a fire lookout and staging area for the local county agency's fire department. The road was dangerous because it was narrow and had sharp bends. The fire department closed it to private vehicle and posted "keep off" signs, but hikers still used it to walk to picnic tables where the hotel used to be.

The county fire department traditionally used its own personnel and equipment to "repair" the road, annually after each storm season, and occasionally multiple times during a storm season. In 2005, two areas were sufficiently damaged that the fire department crews were unable to "repair" the road. My company had an on-call geotechnical services contract and I got the call to help them. This road was secondary access to major communications facilities on Mount Wilson; one of the key pieces of fragile infrastructure, a fiber optics line, had been buried in the bed of the road at an unknown time. It remained operational during and after the 2005 storms; therefore, the road bed had been covered by slough from slopes above the road, but the road had not been displaced enough to break the fiber optics "strain gauge".

In discussions with the county, they said they wanted the road "repaired", and that they had "repaired" a slope in the worst area following severe storms in 1988. They were hoping that I could design a repair that would last more than 30 years, but they were willing to continue with their program of removing slough from the road and filling in "minor" erosion gullies. They also informed me that the county public works department would be reviewing my investigation and design. Having worked on road repair projects for the public works department, I knew what their view of an adequate investigation and acceptable factor of safety design would require. I suggested that the fire department's need was to be able to drive their vehicles to the fire department facilities where the old hotel once stood. I wanted to call the project "restoration of vehicle access" and leave out the words "repair" or "stabilize". After quite a bit of discussion with some pretty high-ranking individuals, the county agreed that the project would be "restoration of vehicle access" and the department of public works would not be involved because it would fall under the category of "maintenance".

The project would be preliminary design of gabion baskets and welded-wire mechanically stabilized earth structures. The wire elements would deform without losing function under future heavy rains that resulted in slope movements. In one area, welded-wire steepened-slope elements were used for ease of construction and efficiency. The investigation consisted to drilling two bore holes just beyond the toe of the main landslide and performing a half-day of seismic refraction surveying across the alignment of the pre-slide road. Aerial photogrammetry was used to develop current topographic information from which a preliminary design and material quantities were developed. The county agreed to have a preliminary design and "field engineering" to make the preliminary design fit the actual conditions. The county selected a qualified contractor with substantial experience of working on difficult slopes and constructing projects with "field engineering".

The restored road bed across the landslide was supported on a welded-wire mechanically stabilized wall. The soils excavated from the landslide mass were used for backfill, and the fill compaction was measured, even though I argued for a method-specification approach, given all of the uncertainties that were inherent in the project. At one place about 95 percent of the way across the landslide, a huge block of rock was encountered. The contractor called and asked if I wanted that block removed; I said "leave that rock right where it is – it's the most stable spot on the road!" The space between the block and bedrock on the edge of the landslide was too small for welded-wire wall elements, so gabion baskets were placed in an unconventional configuration only one basket wide at the base and four

baskets high. To help secure them, rock anchors, eye bolts, and wire rope were used to lash the baskets in place with the anchors drilled into the rock block on one side and the bedrock formation on the other.

No factors of safety were calculated for this project. If factors of safety had been required, the cost of investigation to develop the needed soil and rock parameters could have exceeded the cost of construction of the project. Besides, the roadbed was reestablished across landslide debris – under soaking rain and earthquake loading, no factors of safety would be above 1.0. The success of the project defined as “restoration of vehicle access” did not rely on stability. It relied on remaining passible to county-owned vehicles with repairable damage to the road. Additional details are described in Keaton et al. (2011).

DISCUSSION AND CONCLUSIONS

The two examples described in this paper may be helpful for informing readers of what the author perceives to be a need for standards that allow consideration of approaches that are well grounded in science and engineering, but may not have been widely used for projects that must be approved by regulators. These examples may also be helpful for informing readers that the regulators of today and tomorrow need to be sufficiently informed about the processes that engineering calculations represent that they can review a design that is based on a set of equations or results that goes beyond the prescriptive regulations of the past.

To carry this thought further, the author was principal investigator of a research project to develop guidelines for evaluation of scour at bridge foundations on rock (Keaton et al., 2012). In a presentation to a group of hydraulic and geotechnical engineers at a state department of transportation, I described the observations at five bridges leading to a theoretical approach to characterize the scour process as a rock-water interaction phenomenon, along with laboratory test results, that used unit stream power as the primary variable for flowing water. This was a departure from the customary depth-averaged flow velocity variable. A key comment from one of the hydraulic engineers was revealing. He seemed somewhat frustrated with the elaboration of details that supported the findings that led to the conclusion. In short, he was a “bottom line” kind of guy. His question was, “Why can’t you just give us the equations and forget about all the theoretical stuff?”

Owners of facilities also contribute to stifling innovation. Innovation brings with it some uncertainty. In fact, it may be uncertain uncertainty, or at least seem to be that way. For major infrastructure projects, the owner of the future completed project is likely to be involved in the design, the construction, and the operation of the facility. This is in contrast to buildings that are more likely to be built for commercial purposes by groups that have no intention of occupying them. The latter builder has no interest in life-cycle cost analysis, because the value of the investment in design and construction produces a return is realized during operation and maintenance.

Even for public works agencies that are involved throughout the life-cycle of the project, it seems that the team responsible for developing the concept and planning the project is distinct from the team who designs and constructs the project. Yet another independent team takes over for operation of the facilities. Each of these three teams has a different mission, a different budget, a different schedule, and different metrics for measuring success. Thus, different departments in the same agency may be just as independent and companies that compete for the design services, the construction contract, and the facility operations contract. These departments seem independent because the financing silos for their activities have been institutionalized as independent entities.

Along with the independent financing silos comes a byproduct that further stifles innovation: low-bid contracting. In every competition, one company will emerge as having the Lowest bid, unless multiple companies happen arrive at the same value. Conservative assumptions all along the design process can result is a design that is “safe” from the perspective of passing permit review and not having immediate performance problem that results in litigation against the designer. It may not be “good engineering” and it would likely not meet the definition of sustainability, but it might be a “sustainability” tactic for an engineering company to remain in business. Innovation in low-bid contracting is likely to be in favor of the contractor in the immediate or short term, rather than in favor of project efficiency in the longer term of its life cycle.

Engineering service providers and engineering educators and researchers have opportunities to develop standards that become regulations that invite or even promote innovation. Smart sensor technology allows monitoring of details that were not even considered in designs a few years ago. New sensors and monitoring technology that cannot be imagined today will be developed in the near future; standards and regulations need to allow for these advancements because it will become “just good engineering” in the future. Traditional regulations are indexed to minimum values of key parameters. Because of this, owners are accustomed to paying for the minimum to meet the regulation and obtain a permit. Consultants and contractors are conditioned to provide low-bid estimates and perform at the lowest level that will meet the standard of care, or not be selected for the work. Innovative ideas tend to be dismissed because they result in costs that exceed low bid, even if they result in lower life-cycle costs, because most “projects” are defined as “design and construction” and treated separately from “operation and maintenance”. Owners reject new ideas because regulators’ review questions delay construction and design professionals expect to be paid for responding to regulators’ review questions.

Clearly, both regulatory-ready sustainability and sustainability-ready regulators are needed to enable progress and advance innovative ideas.

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