Simple, But No Simpler

While no single approach to building codes can be simple, reliable, and economical, we *can* have any two of these—and maybe that's just what we need.

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AT THE NORTH AMERICAN STEEL CONSTRUCTION CONFERENCE IN NEW ORLEANS IN APRIL, I HAD A BRIEF CONVERSATION WITH A PROFESSOR FROM A DISTINGUISHED UNIVERSITY, WITH WHOM I HAVE OCCASIONALLY COLLABORATED. He mentioned that he had recently seen me quoted as advocating the most complex building codes possible. I was quite taken aback and immediately denied having ever advocated such a thing. However, upon reflection, and in later conversations with others, I began to understand what he had likely read, and how this could have been either misquoted, misinterpreted, or both.

I think one of the most profound statements I have ever heard came from Albert Einstein: "Everything should be made as simple as possible, but no simpler." In fact, I have been so taken with this statement that it has become a guiding light in my codes and standards development work.

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> **—ALBERT EINSTEIN**

In my view, the purpose of a building code or a design standard is to provide a set of procedures and criteria that will enable the design and construction of safe and serviceable buildings and structures, without constraining construction practice so much that every building looks just like every other building. A building code can accomplish this task and be simple, yet still permit the construction of quite large and complex structures.

Consider for example the Empire State Building and the Golden Gate Bridge. Both of these landmark structures, and many hundreds of thousands of less noteworthy structures, were designed in an era when building codes were quite simple, using design procedures and calculations that could be performed by hand. These structures are clearly safe and serviceable, and we anticipate that they will remain so for many years to come. We could continue to design structures in this manner today, though they may not conform to present building codes, and they would still be safe and serviceable. However, they would not be very economical by today's standards.

This brings me to a second profound statement. I saw it on a poster on the wall of an automobile repair shop. The sign said: "We do Good, Quick, Cheap work—you can have any two. If you want it good and cheap, it won't be quick; if you want it good and quick it won't be cheap; if you want it quick and cheap, it won't be good." So true!

The sign parallels the construction world in that building codes and standards can provide Simple, Reliable, Economical design requirements—you can have any two! Unfortunately, in our present society, with its demands for instant gratification, we want all three. We can't have them. If you want codes that are simple and reliable, the designs won't be economical. If you want codes that are simple and economical, for many structures, they won't be reliable. If you want them reliable and economical, they won't be simple.

Seismic Provisions

First, let's consider earthquake design provisions as an example. Everyone says they are complex. I agree. When I started practicing in the early 1970s, the code had three seismic zones, four structural systems (box, frame, moment frame, and dual), one base shear equation, no drift calculations, no dynamic analysis, and almost no detailing provisions. This code was simple and economical. California engineers liked the 1970 Uniform Building Code (UBC) a lot and thought it resulted in pretty good buildings. Then a succession of nine damaging California earthquakes in a span of 23 years, starting in 1971 and ending in 1994, caused collapses and other severe damage in buildings designed to this building code. We realized that although the 1970 UBC and its predecessors were simple and economical, they just were not reliable. So California engineers—and later, engineers nationwide—began to develop a successive series of code changes intended to make seismic design of buildings more reliable.

Since engineers and their clients weren't willing to walk away from being able to design reasonably economical buildings, out of necessity the seismic criteria became quite complex. This complexity exhibits itself in several forms: We have mapped contours of ground motions instead of seismic zones; this is for economy so we can reduce the amount of force some people design for. We have 75 structural systems; again, this is for economy, so engineers can choose the structural system that will give the optimum design for a given building. We have dynamic analysis; this was for reliability in that we could better estimate the demands on our buildings, but also economy, as dynamic analysis will sometimes let us design lighter structures. We have extensive detailing requirements; this is about reliability, but also economy, because if we designed our structures stronger—a lot stronger—we would not need the detailing.

Wind Provisions

A similar growth in complexity can be seen in the wind provisions over this same time period. Again, 30 years ago, we designed for 20 psf wind load in the lower stories and amplified this load in upper stories. We didn't differentiate between cladding and elements of the main wind force resisting system, nor did we differentiate between positive pressures and suction pressures. We didn't recognize the effects of pressure concentrations that occur at eaves, ridges, and corners. We didn't check drift. This code was simple and, we thought, relatively economical, and those of us who used it were happy.

Unfortunately, it wasn't very reliable. While few buildings collapsed as a result of wind, cladding and roofing, particularly on light steel buildings and light wood frame buildings, was pulled from structures during strong wind storms. Tall buildings shed glazing panels, elevators sometimes were unable to run up and down on windy days, and people on upper floors of high-rise buildings occasionally got seasick.

So again, codes and standards became more complex to make them more reliable. We began to recognize the suction pressures on rear and lee walls; we recognized and designed for the higher pressures at eaves and ridges. However, we also wanted our designs to be economical, so we recognized that high pressures occur on localized areas of a building's exterior, and we could design the main wind force resisting system for lower loads than those for cladding and secondary members such as girts and purlins. The code became complex as we added pressure zones over the skin of a building, internal and external pressure coefficients, and recognition of dynamic effects in flexible structures. Then we decided that buildings on hills and escarpments see higher wind forces than buildings on flat plains, so rather than making everyone design for these higher forces, we developed topographic coefficients. This all seems reasonable, unless you are a designer in a region where wind loads never control the design. The same could be said for the seismic provisions, if you are in a region prone to hurricanes and where seismic never controls the design. We won't even talk about snow load and the way drifts are calculated around roof projections that aren't even located when the engineer performs the roof design.

Keeping it Simple

The result of all this, of course, is that engineers around the country have been pleading for simpler codes. Both the wind and seismic communities have heard these pleas, and both attempted to respond. Some might say that my viewpoint is somewhat prejudiced, but I think the seismic community did this more successfully then the wind community. The simplified seismic design provisions are back to one base shear equation, a limited number of structural systems, no drift calculations, and no dynamic analysis. The seismic community recognized that if you want it simple and reliable, it can't be cheap, so the design forces for buildings using the simplified approach are larger and more conservative than if you use the more complex methods of the standard design procedures. Also, the simplified approach is limited to buildings of regular configuration where many of the complexities associated with irregularities need not be considered.

The wind community also developed a simplified procedure, but in my opinion, they didn't do it the right way. They tried to be simple, reliable, and economical. It can't be done. The simple wind procedure entails multiple load combinations to capture torsion and a complex map of zones over a building's skin where wind pressures vary from zone to zone. I think they have succeeded in being reliable and economical, but not simple. Consider that for many buildings, these new procedures will allow design for pressures as low as 10 psf, half of what we designed for 30 years ago. Would it really add that much cost to a building if we went back to 20 psf and got rid of the different wind pressures zones over the building exterior and forgot about torsion? I wonder. I know that where I design, it wouldn't matter much. I could still demonstrate, with simple but larger wind loads, that seismic controlled the design of most structures.

Designing for the Future

This brings me to where I believe building codes and design standards should head in the future. Complex design procedures will continue to be needed so we can design buildings that are both reliable and economical. However, for most buildings, one, or perhaps a few, load conditions will dominate the design. For these load conditions that do not control a design, we should permit the use of very simple, very conservative (but uneconomical) procedures. The only place I have ever had to design for both hurricane force winds and large-magnitude earthquakes—and both controlled significant aspects of the design—was on the island of Guam. Everywhere else (or nearly everywhere else), the lateral design of most buildings will be controlled either by wind, seismic, or general considerations of stability, while the other loading conditions will not have significant impact on the design. For some buildings, the design will be controlled by the basic gravity load system, and wind, seismic, and stability will not be significant factors in the building's structural design or ultimate cost. Why not allow for the use of very simple, very conservative design procedures where the loading condition doesn't really matter? If seismic forces are twice the wind forces on a building, does it really matter if we make the wind forces 50% larger than they have to be, so that engineers can use simple procedures? It won't really affect the building cost that much.

So here is my model for the future of building codes and standards: a set of relatively complex procedures that combine reliability with economy for most structures, coupled with a series of very simple procedures that are broadly applicable to most buildings and will be very conservative and therefore reliable—but not particularly economical—when they are used for a load condition that will actually control design.

Some engineers may wish to use these simple procedures, even when they control the design; others will not. Presumably, engineers will charge increased fees when they use the complex procedures, and the owners should pay these increased fees, for they will reap the benefit in terms of more economical buildings.

But my model is not complete yet. Performance-based design procedures have always been a part of the codes, through the provisions that permit the use of alternative means and methods. Although extensive use has been made of these approaches in design for fire and life safety protection, until recently there has been scant use of performance-based approaches for structural design of new buildings. However, within the last few years, a large number of very tall buildings in the western U.S. have been designed using a performance-based approach for their seismic resistance. This has permitted the development of a number of structures that would likely not have been constructed otherwise. In my opinion these structures are both reliable and economical. This approach desperately needs to be preserved and carried forward in the codes, and should be done in a manner that it is not itself overly prescriptive. The important thing about performance-based approaches is that they permit engineers to push the envelope and develop new ways of doing things.

The prescriptive procedures in building codes, whether simple or complex, are quite restrictive on the configuration, materials, and detailing of structures, as they must be in order to assure reliability. It is impossible to develop prescriptive procedures that will reliably address configurations, materials, and systems that haven't yet been conceived. Yet I believe it is essential that we not constrain the profession by making it excessively difficult or risky to use new ideas before prescriptive provisions exist.

A Work in Progress

Presently, there are significant efforts in the seismic, blast, and fire protection communities to develop performance-based design procedures. These are honorable and important efforts and should be followed with similar efforts in the wind and snow communities. However, it is extremely important that we do not fall into the trap of over-prescribing the way a performance-based design is accomplished. If we over-prescribe, we will only succeed in needlessly constraining the very freedom of design that performance-based approaches can and should provide. Rather, performance-based development efforts should focus on the establishment of appropriate performance goals or objectives and the development and validation of tools that enable the prediction or assessment of a design's ability to achieve these objectives. We should then take great care to ensure that we permit the use of alternative tools. Enactment of these approaches will require careful thought and understanding of the nature of the hazards and the behavior of the structures. This level of understanding might well be beyond the training and approach of many engineers, but this should not discourage those who are willing to invest the effort into obtaining the necessary knowledge and capability.

In summary, the building codes of the future should incorporate three options for every loading condition. The first is a simple and reliable, but not particularly economical, approach that should be widely applicable to many buildings. The second is a reliable and economical approach that may not be particularly simple to use, but is within the capabilities of all engineers if they are willing to take the time to learn what they must do. The third is a performance-based approach that will likely require too much knowledge and training to be practically used by many engineers, but will enable us to push the boundaries of our technology and find new ways to develop reliable and economical structures. In this way, I believe, we can successfully make things as simple as possible, but no simpler—while balancing the desire to have simple, reliable, and economical building codes. MSC