DON’T GET BURNED BY PERFORMANCE-BASED DESIGN

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At FM Global, we like performance-based design. However, fire is highly complex, and this approach to code compliance can be dangerous.

Performance-based building design is an attractive concept. It means designing and evaluating a structure based on what it can do, not on what design specifications have been dictated by a code or tradition. It’s about the end, not the means.

Performance-based design is the antithesis of prescriptive design, which specifies the permissible materials, methods, dimensions and equipment needed to comply with building codes.

Like many of our clients, we find performance-based design appealing, because it allows flexibility and innovation. Why constrain architects and engineers to repeat the past when they can build more beautiful, higher-functioning and cost-effective structures? Some of the most iconic buildings were constructed when architects, designers and engineers ventured beyond standard building codes. Although they broke the rules, they satisfied the intent, achieving the requisite structural and functional performance goals.

Because fire’s behavior is hard to predict in new designs, a performance-based fire protection design is, by definition, unproven. There is much that researchers still do not know about fire, but they do know that the non linearities are real.

When it comes to fire protection, however, performance-based design is a problem.

Here’s why.

Most people don’t realize the primary goal of fire protection, according to many building codes, is life safety—to get everyone out of a building before it collapses or before heat and smoke make survival unlikely. Yet it is difficult, if not impossible, to prove that an untested building design—one that falls outside proven prescriptions—will deliver the required fire protection. There are also questions about the ability of fire protection engineers to create effective nonstandard designs and the ability of regulators to evaluate them. The computer models that are used to demonstrate the performance of these designs haven’t proven valid for the same applications, and it’s difficult for code officials to sort out the good and proven from the showier but unproven.

As a commercial property insurer, FM Global discourages our clients from experimenting with alternatives to scientifically based fire engineering guidelines which, by their nature, are prescriptive. For that reason, we are generally opposed to broad application of performance-based fire protection design.

The challenge

Fire protection is not a good fit for performance-based codes because the engineering involved is far more complex than other types of engineering. In structural engineering, proving the viability of an innovation is comparatively easy. An engineer can devise several ways for a building to support a given load by adjusting the types, dimensions and configurations of structural members. The performance of each configuration will be easy to calculate based on established materials science and the well-understood laws of physics. Although structural design can sometimes be non linear (i.e., small changes can make a big difference), fire is always highly non linear.
This makes fire protection engineering difficult. Because fire’s behavior is hard to predict in new designs, a performance-based fire protection design is, by definition, unproven. There is much that researchers still do not know about fire, but they do know that the non-linearities are real. Changing even small variables in fire events—ignition sources, configurations, fuels or suppression mechanisms—can produce dramatically disparate results. Each variation in a fire event creates an entirely different output is eye-catching, algorithms are only approximations of fire behavior. The limitations of software demand final validation through real-world testing.

A real-world test is an experiment in a fire lab where a new material, storage configuration or suppression system is subjected to actual conditions. We often do real-world testing for our clients in our Fire Technology Laboratory when they propose using new storage configurations, materials or fire suppression technologies. If a design passes our tests, then it can become an alternative that FM Global recommends as “deemed to satisfy” a prescriptive fire protection code, based on scientific research.

Engineers’ and regulators’ qualifications raise concerns

Other concerns with performance-based design are the background and knowledge of fire protection engineers and regulators. These qualified individuals have strong credentials, but there is no evidence that, in the aggregate, sufficient fire protection engineering knowledge for unproven design exists to support safe performance-based design for fire risk on a broad scale. Fire risk expert B.J. Meacham, Ph.D. explored this concern in a seminal article in Fire Protection Engineering (Q3 2018). In a survey of 400 people in 40 countries, he found that only about 5-10 percent of fire safety designs were full performance-based designs. What’s interesting is why.

“Several reasons were articulated for the relatively small number of performance-based designs, including lack of qualified and competent fire safety engineers, lack of qualified and competent review and approval authorities, lack of regulated/required qualification mechanisms, lack

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For more than 100 years, FM Global has been conducting scientific research and product testing to develop new engineering guidelines for new building designs and existing facilities.

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1At FM Global, we have invested a great amount of time and effort in developing FireFOAM, a unique physics-based fire model. To the extent that we have compared it with actual data for the same conditions, we trust it. At the same time we understand that fire is nonlinear and unpredictable, and cannot always be flawlessly modeled in computer software. The limitations of modeling software demand real-world testing as final validation. This is why we spoke out in May 2018 about desktop assessments of building cladding.
of clear performance metrics within the regulations or design guidance, and lack of verification methods for real performance-based designs.”

Fewer than 1 in 4 respondents believed there were enough qualified fire safety engineers in their country across all areas (e.g., design, review and approval, peer review, enforcement). About 1 in 4 said “only qualified fire safety engineers were undertaking fire engineering designs.”

“The survey data suggests that the lack of qualified fire safety engineers is leading to unqualified persons developing performance-based designs,” Meacham concludes. “If the authorities then lack the competencies for reviewing such designs, some very questionable designs may result.” This is deeply concerning and is, unfortunately, supported by FM Global’s own experience.

Adhere to established solutions
FM Global’s fire protection recommendations are supported by analysis or by data analyzed by our fire scientists including many of whom who hold doctorate degrees, and validated by experiments in our Fire Technology Laboratory. These recommendations provide trustworthy guidance that has often been adopted by regulatory authorities, with respect to recommended products and their proper installation.

For more than 100 years, we have been conducting scientific research and product testing to develop new engineering guidelines for new building designs and existing facilities. This work has enabled many of our clients to innovate and save money. At the same time, our work has shed light on attractive innovations that entailed significant fire risk.

At FM Global, we truly understand the appeal of performance-based design. In practice, however, we strongly recommend that our clients continue to adhere to fire protection designs that have been scientifically proven. Your business, and the people within it, depend on it.

We are eager to answer any questions you have about preventing fire loss on your property and can direct you to further resources about this topic.

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Full-scale fire testing
FM Global’s Fire Technology Laboratory at its Research Campus in West Glocester, Rhode Island, USA, is the largest facility of its type in the world. www.fmglobal.com/research

At 108,000 square feet (10,033 m²), its size allows researchers to replicate six-story warehouse fires.

Full-scale fire testing helps our researchers and engineers develop property loss prevention solutions that minimize operational downtime, supply chain interruption and loss of market share for our clients.

The laboratory also features several smaller labs for intermediate- and small-scale burn testing, enabling FM Global researchers to study a broad range of materials and arrangements, helping clients reduce their risk and stay in business.