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# Engineering and the Art of the Fail

By CORNELIA DEAN

## **TO FORGIVE DESIGN**

### **Understanding Failure**

By Henry Petroski

410 pages. The Belknap  
Press of Harvard  
University Press. \$27.95.

In May 1987 the Golden Gate Bridge had a 50th birthday party. The bridge was closed to automobile traffic so people could enjoy a walk across the spectacular span.

Organizers expected perhaps 50,000 pedestrians to show up. Instead, by some estimates, as many as 800,000 thronged the bridge approaches. By the

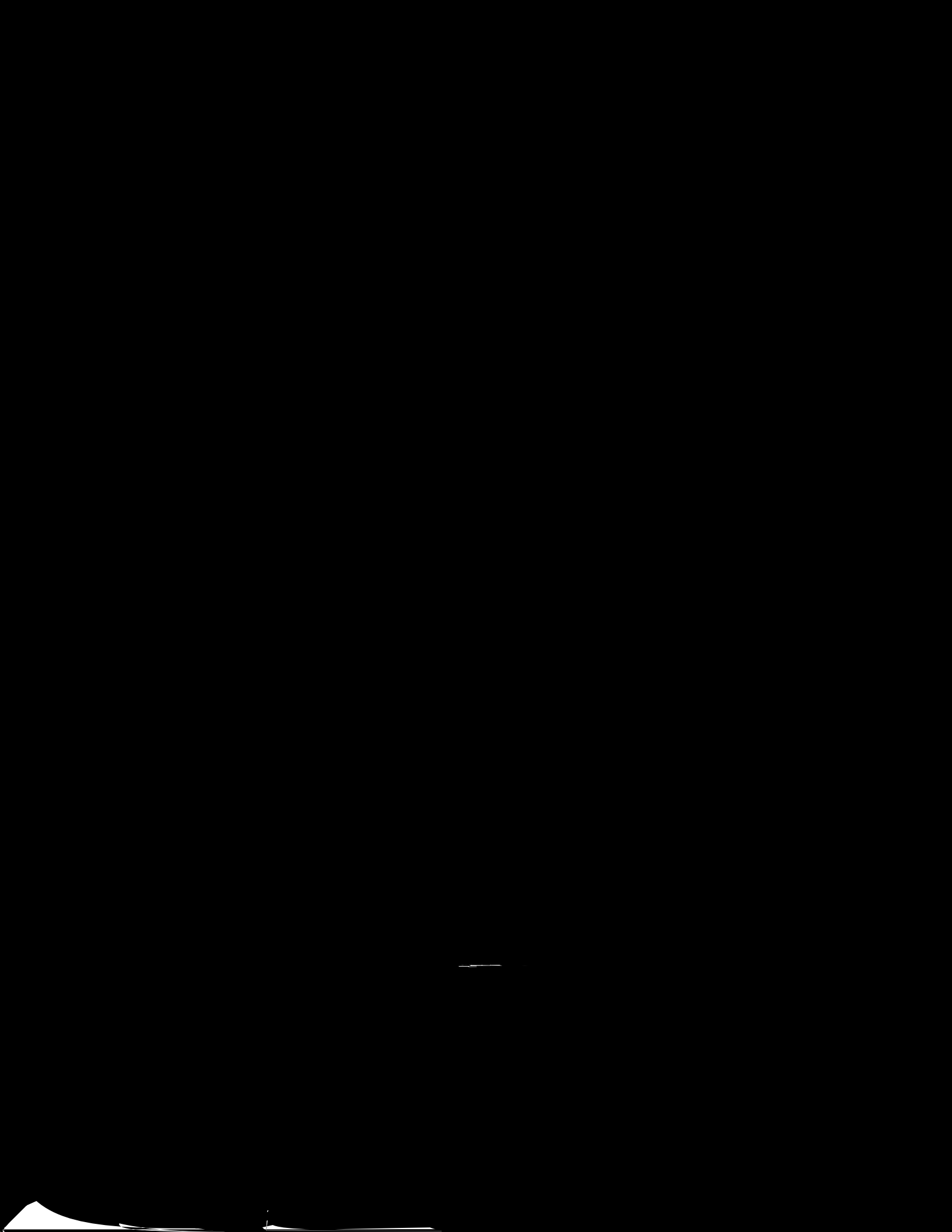
time 250,000 were on the bridge engineers noticed something ominous: the roadway was flattening under what turned out to be the heaviest load it had ever been asked to carry. Worse, it was beginning to sway.

“Though crowds of people do not generally walk in step, if the bridge beneath them begins to move sideways — for whatever reason — the people on it instinctively tend to fall into step the better to keep their balance,” Henry Petroski writes. “This in turn exacerbates the sideways motion of the structure, and a positive feedback loop is developed,” making matters worse and worse.

This time disaster was averted. The authorities closed access to the bridge and tens of thousands of people, caught in pedestrian gridlock, made their way back to land, a process that for some took hours.

The story is one of scores in “To Forgive Design: Understanding Failure,” a book that is at once an absorbing love letter to engineering and a paean to its breakdowns.

Disaster has long been grist for Dr. Petroski. His first book, in 1985, was “To Engineer Is Human: The Role of Failure in Successful Design.” Since then he has written widely on failure, in other books and in a regular



Perhaps a good design is constructed with shoddy materials incompetently applied, factors Dr. Petroski says were at play in the concrete woes of Haiti's housing stock after its 2010 earthquake.

Or perhaps a design works so well it is adopted elsewhere again and again, with incremental, seemingly innocuous improvements, until, suddenly, it does not work at all anymore. That was the case in one of the most notorious engineering failures, the collapse of the Tacoma Narrows Bridge, in Washington State in 1940.

Its design was not that different from the design of other successful bridges. But people wanted an elegant structure, so they built it narrow, just two lanes wide. Shortly after it opened, in winds of only about 40 miles per hour, it began to sway, eventually contorting itself until it collapsed.

In a way, failure has shaped Dr. Petroski's career. As a young engineer at Argonne National Laboratory he worked on the fracture mechanics of nuclear-reactor vessels. But when job prospects dried up after the accident at Three Mile Island, he took a job at Duke University, where today he is a professor of civil engineering.

Readers of his earlier books will encounter stories they have heard before in "To Forgive Design." But they will encounter new stories, too, and a moving discussion of the responsibility of the engineer to the public and the ways young engineers can be helped to grasp them.

After the 1907 collapse of a bridge under construction in Quebec, engineers in Canada instituted a ceremony by which new graduates entering the profession received iron rings meant to remind them of their responsibilities. A variation of this practice is spreading in the United States, even as this country struggles to enhance its engineering success in the world economy.

People who study the ecology of innovation say one of our biggest advantages may be our willingness to accept failure, however distressing, as an inevitable byproduct of ambition. In the United States, if some unanticipated factor causes your good idea to fail, relatively little stigma attaches to you. In fact, you will hear people in Silicon Valley say that if you have not gone bankrupt at least once or twice, you're not trying hard

enough.

“Success is success but that is all that it is,” Dr. Petroski writes. It is failure that brings improvement.