



# To Forgive Design: Understanding Failure

By Henry Petroski



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When planes crash, bridges collapse, and automobile gas tanks explode, we are quick to blame poor design. But Henry Petroski says we must look beyond design for causes and corrections. Known for his masterly explanations of engineering successes and failures, Petroski here takes his analysis a step further, to consider the larger context in which accidents occur.

In *To Forgive Design* he surveys some of the most infamous failures of our time, from the 2007 Minneapolis bridge collapse and the toppling of a massive Shanghai apartment building in 2009 to Boston's prolonged Big Dig and the 2010 Gulf oil spill. These avoidable disasters reveal the interdependency of people and machines within systems whose complex behavior was undreamt of by their designers, until it was too late. Petroski shows that even the simplest technology is embedded in cultural and socioeconomic constraints, complications, and contradictions.

Failure to imagine the possibility of failure is the most profound mistake engineers can make. Software developers realized this early on and looked outside their young field, to structural engineering, as they sought a historical perspective to help them identify their own potential mistakes. By explaining the interconnectedness of technology and culture and the dangers that can emerge from complexity, Petroski demonstrates that we would all do well to follow their lead.

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## **Editorial Review**

### Review

[An] authoritative text about the interrelationship between success and failure in the engineering enterprise...Petroski's most gripping passages are his Sherlockian dissections of engineering fiascos and the importance of learning from the vast archive of forensic analyses. (*Kirkus Reviews* 2012-02-01)

Though his focus here is primarily on bridges, Petroski extends his analysis to include the sinking of the Titanic, the mid-flight explosion of TWA Flight 800, the Challenger tragedy, the Y2K computer programming crisis, and the Deepwater Horizon spill in the Gulf of Mexico. Each has its own unique set of human, mechanical, and engineering failures, and Petroski does a terrific job of identifying and communicating not only what went wrong, but what was learned from the failure and how that knowledge has since been put into practice. Fellow engineers and armchair scientists will get the most out of the book, but even the layman will find Petroski's study to be accessible, informative, and interesting. (*Publishers Weekly* 2012-02-06)

Petroski follows up his first book, *To Engineer Is Human: The Role of Failure in Successful Design*, with this examination of human failure. In the previous title, he primarily considered mechanical and structural failures. Here, he looks not only at how people contribute to the failure of engineering designs but also at how analyzing those failures can improve subsequent models. He considers many different types of failures, from several infamous bridge collapses to carefully designed intentional failures, which are engineered specifically to prevent greater failures. In each case, Petroski goes beyond an explanation of the mechanical failure itself to point out how humans created these and other problems through systemic mistakes. (Carla H. Lee *Library Journal* 2012-02-15)

When a plane crashes or a bridge collapses, faulty engineering is the usual suspect. But in seeking the roots of failure, we should look beyond design, says engineer Henry Petroski. We must probe the political and economic imperatives that shape purposes and use. In this follow-up to his influential *To Engineer is Human*, Petroski argues that accidents such as the Deepwater Horizon oil spill are the result of faults as much in "human machinery" as in mechanical devices. He praises software developers for learning from structural engineering about how to report and analyze mishaps. (*Nature* 2012-03-01)

A rewarding read. (Jonathon Keats *New Scientist* 2012-03-17)

By critically examining the interdependency of people and machines related to bridge collapses, airplane crashes and space shuttle failures, Petroski discovers that understanding failure is the only way to bring successful design and engineering into the future. (Megan Wood *Salon* 2012-03-25)

Nonengineers needn't worry that the book will be too dense with details; Petroski makes the science easily understandable...[This is] a book that satisfactorily explains why our determination to push the boundaries guarantees both failure and triumph. (James F. Sweeney *Cleveland Plain Dealer* 2012-04-05)

[A] fascinating and occasionally unnerving history of engineering failures...After reading this book, one might be tempted never to venture across a bridge again. But of course that would miss Petroski's goal: to show how engineers learn from failure and improve their designs...For those who enjoy reading about girders and trusses, *To Forgive Design* is, yes, riveting...[Petroski] amply shows the wisdom of the proverb that failure is a good teacher. Even a collapsed bridge leads somewhere. (Matt Ridley *Wall Street Journal* 2012-

04-10)

Engineering is interesting when it works, but much more compelling when it doesn't. Petroski may be one of his profession's establishment figures, but his key finding is highly critical: because most engineers don't know much about the history of engineering, complacency and gee-whizz design software is likely to foment a fairly regular incidence of potentially catastrophic structural failures...Much of the information will be of great interest to engineers and designers...The most brilliantly explained engineering failure concerns the ocean-bed blowout involving the Deepwater Horizon oil rig in 2010. Petroski's exposition is immensely detailed and benefits from being linear in its narrative. This section of the book is exemplary in its remorseless exfoliation of the technical and commercial reasons for the incident. (Jay Merrick *The Independent* 2012-05-19)

Americans are encouraged to believe that failure is not an option, but author Henry Petroski regards it as just about inevitable. A professor of civil engineering and history at Duke University, Petroski began his writing career with *To Engineer Is Human: The Role of Failure in Successful Design*, an influential work that deals with mechanical and engineering failures. This huge sequel devotes much more attention to the interplay between human beings, machines, buildings and disaster. It's exhaustive, relentless, often exhilarating--and given its technical nature, surprisingly readable...If you're already a bit phobic about flying in a plane, crossing a suspension bridge, or even driving a car, *To Forgive Design* is probably not for you...Petroski chronicles the story of failure with a measure of affection reminiscent of a biographer of Attila the Hun who develops a grudging fondness for his subject. But whether or not the latter had redeeming qualities, the former surely does: Failure reminds us to avoid the sin of pride. I thoroughly enjoyed *To Forgive Design*, even down to the gloomy quote from the famously gloomy writer Samuel Beckett: "Ever tried. Ever failed. No matter. Try again. Fail again. Fail better." (Joe Queenan *Barron's* 2012-05-05)

A book that is at once an absorbing love letter to engineering and a paean to its breakdowns... This book is a litany of failure, including falling concrete in the Big Dig in Boston, the loss of the space shuttles *Challenger* and *Columbia*, the rupture of New Orleans levees, collapsing buildings in the Haitian earthquake, the Deepwater Horizon blowout, the sinking of the *Titanic*, the metal fatigue that doomed 1950s-era de Havilland Comet jets—and swaying, crumpling bridges from Britain to Cambodia... [Readers will encounter] a moving discussion of the responsibility of the engineer to the public and the ways young engineers can be helped to grasp them. (Cornelia Dean *New York Times* 2012-07-12)

For more than two decades, Petroski has been delighting and educating readers with tales of engineering failures and how they can lead to safer technology...Always technically well informed and gifted with a comfortable, engaging storytelling style, Petroski shows readers how engineering design is a compromise between the ideal of perfect safety and the practicalities of limited resources. The lesson is that engineering makes advances through failure, but only if the lessons that failure teaches are applied to future projects...*To Forgive Design* succeeds in conveying Petroski's message in a way that can be appreciated by the general reader and put to practical use by engineering students of all levels. (K. D. Stephan *Choice* 2012-08-01)

*To Forgive Design* remains a largely accessible, important contribution to the growing library of failure. (Colin Dickey *Los Angeles Review of Books* 2012-08-03)

Mustering a truly staggering array of examples of past engineering failures, **Petroski** makes the case that failure is a necessary component of technological development, and that structures, machines and other engineered devices do not exist in isolation, but instead are designed and used within a tangle of competing constraints and unpredictable scenarios...At his best, Petroski is a compelling storyteller, and his recounting of past disasters and near-disasters can be fascinating. In addition to several detailed but well-paced

narratives of familiar failures such as the Space Shuttle *Challenger* explosion, the book contains a great deal of intriguing arcana...Petroski's greatest asset as a writer is his impressive historical erudition. He seems to have an infinite file of meticulously detailed case studies that illustrate his points, and any thought of just how long he must have spent researching inspires mild fear. He has written prolifically for nearly three decades on the topic of failure in engineering, and there is no doubt whatsoever that he knows what he's talking about...I would sincerely recommend *To Forgive Design* to anyone with a particular interest in historical engineering fiascos. (Colin McSwiggen *Literary Review* 2012-11-01)

[An] engaging book...Reading these pages reminds us of how many spectacular failures have occupied the news pages for a week or two in our lifetimes...If **Petroski's** account proves anything, it's that the forces of the real world may eventually prevail on even the mightiest structures. (Bill McKibben *New York Review of Books* 2013-06-20)

#### About the Author

Henry Petroski is the Aleksandar S. Vesic Professor of Civil Engineering and Professor of History at Duke University.

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