Len Fisher

Exciting structures

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High and mighty
The Eiffel Tower is a great example of a truss in action.

Super Structures: The Science of Bridges, Buildings, Dams and Other Feats of Engineering
Mark Denny
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Mark Denny's latest book, *Super Structures*, is designed to help non-scientists share and enjoy the way that we scientists view and think about the world of physical structures. My first step in reviewing it, therefore, was to try it out on my non-scientist friends. Without exception, they were intrigued and wanted to read more.

The book is organized in a logical way, from basic theory to applications, and benefits from the author's decision to focus on just one structural element: the truss. This is not, as Denny points out, a medical device, but an arrangement of beams and struts designed for mechanical stability. Concentrating on the truss is a neat idea, and it works. In the design of different types of truss, the balance of tensile and compressive forces that underlies successful structural engineering is seen at its simplest and most understandable. The author takes full advantage of this simplicity by first describing the balance of forces and then showing how it can be used to understand the stability of structures that range from Moorish arches and the Eiffel Tower to massive concrete dams.

In addition to these lofty structures, Denny also uses homelier illustrations to drive home his points. He describes, for example, the annual "spaghetti bridge" competition run by Johns Hopkins University, in which competitors build bridges from sticks of dry spaghetti glued together. The bridge that supports the greatest load is the winner, while, to make things more difficult, the bridge itself must weigh no more than 750 g. One recent winner designed a bridge on the truss principle that supported an impressive 56 kg, but this was far from a record: in a worldwide competition run by Okanagan College in British Columbia in 2009, a spaghetti bridge designed by the Hungarians Aliz Totivan and Norbert Pozsonyi supported a load of 443 kg despite weighing less than a kilogram itself.

Such illustrations catch the eye, but they do not really stand comparison with the masterly descriptions in J E Gordon's *Structures: Why Things Don't Fall Down*. Published in 1978, Gordon's book set the benchmark for books on structural engineering, and few popular-science or engineering writers have yet matched his prose style. Consider Gordon's description of the stresses in a pressure vessel: after explaining that in the wall of a cylindrical pressure vessel, the circumferential stress is twice the longitudinal stress, he notes that "One consequence of this must have been observed by everyone who has ever fried a sausage. When the filling inside the sausage swells and the skin bursts, the slit is almost always longitudinal." It is a lovely example – simple, easily understood and vivid.

What Denny's book lacks in this respect, however, it at least partly makes up for through its relative abundance of illustrations. These add considerably to the interest and clarity of the book, and encourage the reader to look at structures in a new way, recognizing that aesthetics resides as much in the balance of forces as it does in the actual shape. My favourite illustration (as a diagram accompanied by a practical example) shows how two barrel vaults intersect to give an intrinsically stronger groin vault – something that is not easy to put into words.

The real point of the book is to get the non-scientific reader thinking about structures in a new and scientific way. The profusion of illustrations certainly helps, and so does Denny's undoubted mastery of the short description (even if it never quite rises to Gordon's level). Almost every paragraph contains some point of interest that encourages the reader to keep reading, no matter where the book may have fallen open.

I confess to finding Denny's approach somewhat patronizing at times. At the start, for example, I did not need to be told that the author "hope[s] that the title, *Super Structures*, gets across the subject that we will tackle". However, non-scientists to whom I have shown the book have been impressed by its clear simplicity. Above all, they have been pleased by the absence of equations, which are confined exclusively to an appendix. Equations, it seems, are still a barrier to sales.

To his credit, Denny does a lot to overcome their absence by getting the reader to consider the balance of forces in a visual, "back of the envelope" way, and presents many interesting examples that are designed to get readers thinking. He points out, for instance, that if we could fit the Eiffel Tower neatly into a giant cylindrical box, the air in the box would weigh more than the tower. This example, as with many of his others, may be familiar to scientists and engineers, but to my non-scientist friends they were an exciting and original revelation.

Ultimately, books intended to make science and engineering more accessible have their greatest value when they not only explain the basic ideas and their applications, but also share the satisfaction and excitement that we scientists gain from understanding how things work. This is true whether those things are physical structures, biological organisms or the universe itself. If we are to succeed in making science an integral part of our wider culture, then we need more books that perform this task. Denny's new book is perfused with this sense of excitement, which adds greatly to the enjoyment of reading it. On this account alone, as well as the clarity with which it is written, it is to be recommended.

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