Black Boxes, Black Books, and Black Swans

Modern computer structural design methods allow complex analyses to be completed quickly and efficiently, but do not require the operator to understand the design process. Experienced engineers are rightly wary of this approach; incorrect input may go unnoticed and faulty design procedures may be buried within the computer code, but seemingly high quality computer output may be reviewed with less care than calculations produced by hand. The approach to structural design is often discussed in terms of computer versus hand calculations, but in my opinion this is a false dichotomy. Certainly it is possible to feed garbage into a black box and get garbage out, but respected text books may also contain errors, or may be applied inappropriately. Computers may be treated as "black boxes", but written works may also be treated as "black books", and either approach can lead to serious errors in the design output.

A different approach is required to achieve reliable results, based on an understanding of structural behaviour, a knowledge of what can go wrong, and a consideration of the possible consequences should the worst happen. Understanding at this level can be based on analysis requiring no calculation, as in a series of short lectures produced by Dr. David Brohn, and available on You Tube (The Behaviour of Simple Beams, https://www.youtube.com/watch?v=khuPy_apnsE). Given a good understanding of the basic behaviour, computer analysis provides an opportunity to apply, enhance and verify that understanding for specific applications, and to investigate the real behaviour of structures in situations where hand calculations would allow only an over-simplistic approach. Applied in this way, far from being a black box, computers can provide a window onto structural behaviour that enhances understanding.

A good understanding of structural behaviour, and appropriate analysis are then two essentials for reliable structural design. A third requirement, and one that I think receives less attention than it deserves, is a consideration of how the structure might behave under conditions that are totally unexpected; the "Black Swans" of the title. In his 2007 book "The Black Swan", which deals with the unexpected mainly in relation to economics, Nassim Taleb makes many points that are equally applicable to engineering, but three particularly attracted my attention. First that the concept of the black swan is as old as the first century AD Latin poet Juvenal, who wrote of a "bird as rare as a black swan"; likewise unexpected events are often found with hindsight to be something that others knew of, and should have been planned for. Secondly black swan events are by definition unpredictable, but systems (and structures) can be and should be sufficiently robust to withstand the unexpected without total failure. Thirdly black swan events are not always bad. Rare events, unnoticed phenomena, or new developments in other fields can provide opportunities for innovation to those prepared to look outside the bounds of the known and widely accepted.

A good understanding of underlying theories, correct application of this understanding to specific structures, and planning for the unexpected are the three essentials to minimising risk in structural design. Attendance at Concrete Institute seminars can help in all these areas, but here I want to focus on the last, and the opportunities for expanding your

knowledge of the thoughts and practices of leaders in the art of the design of concrete structures, through attendance at the Institute's National Seminars. These full day events provide not only the opportunity for in depth technical content, but also the chance for interaction with both the presenters and other attendees. The next series in November will deal with durability in concrete, presented by five of the authors of the Institute's forthcoming durability publications. I strongly recommend attendance, and interaction with all involved.