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Autor: Cornell, C. Allin

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Free Discussion / Discussion libre / Freie Diskussion

C. ALLIN CORNELL
M.I.T.
Cambridge, Mass.

I should like to comment on a theme, or perhaps better a conflict, running throughout the discussion in this symposium--namely deterministic vs. probabilistic, physics vs. statistics, or even science vs. engineering. When put to an ultimate test, it is impossible to distinguish between "random" ("inherently variable") factors and "non-random" factors in which only professional ignorance or human volition are involved.

In design we are all apparently prepared to treat as stochastic variables such factors as yield strength of steel, the maximum annual wind velocity, and the maximum lifetime earthquake intensity at a site. Yet, upon closer analysis each can be separated into identifiable, systematic, predictable compoments. Several here have discussed these components of steel strength. I have heard a meteorologist claim confidently that his science knows enough about the mechanics of their system that, given enough data and a big enough computer, they could predict every aspect of the weather including local wind velocities for years in advance. Tectonic earthquakes are caused by mechanical processes that are, at the moment, very incompletely understood, but hardly beyond the competence of man to know better and eventually predict with some accuracy.

If this is true, can we still treat these variables as random variables? Of course we can, simply because it is useful to do so. It will lead to better engineering design in the form of a better, more economical allocation of material and resources. In short, any probability assignment is an intellectual concept, not a physical attribute, such as length or weight. All probabilities are convenient fictions, simply very useful, quantitative measures of the ever present uncertainty of someone or some profession.

No coin has an inherent probability of p of coming up heads when flipped. I would be very disappointed in modern engineering mechanics and computers, if, given sufficient initial and boundary conditions, they could not predict precisely the outcome of any flip. It might, however, take several years to make the prediction. If a dollar rides on your predicting whether there will be more heads than tails in ten flips, you would be advised to base your decision on the position that there is a fixed <u>probability</u> of coming up heads on any flip. If your life depended on your prediction of a single flip, you would probably devote your career to the indicated mechanics and computers, not the mathematical probability theory of independent Bernoulli trials.

So, too, in engineering, probability should be used because it is the most effective way known to treat uncertainty in design. Its use should not interfere with or obscure engineering scientists in their search for better and more useful understanding of the governing physics or phenomenological evidence. Nor need confirmed engineering probabilists despair. These scientific results will reduce but never eliminate our profession's uncertainty. Nature is too complicated to be predicted by the handbook formulas necessary for conventional design practice.

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HERMANN BEER
Prof. Dr.
Graz

In their very interesting paper, Professor Tall and Dr. Alpsten mentioned that it is possible to predict the behaviour of a compression member provided that we have a thorough knowledge of the properties and geometry of the material. I would like to extend this statement by considering the entire safety problem. In his General Report, presented at the 8th IABSE-Congress, one of the leading statisticians in engineering science, Professor A.M. Freudenthal, stated that the principal theoretical problems are the existence of non-random phenomena and the impossibility of observing the relevant random phenomena within the ranges that are significant for safety analysis. Furthermore, statistical results can lead to errors if sufficient data are not available. The behaviour of a structure is somewhat complicated and there are so many different types of structural components and structures that it seems to be impossible to consider the safety problem in a purely probabilistic manner. Therefore, we have to utilise all the deterministic methods that may be helpful in predicting the behaviour of the structure until failure occurs.