

Limit-state Design

In the life of the modern structural engineer there are three design paradigms:

- Allowable stress design, ASD
- Limit-state design, or load and resistance factored design, LRFD
- Performance-based earthquake engineering, PBEE

Augustin Cauchy invented the concept of stress in 1822. The allowable stress format says that the limiting stress to design against is the predicted stress divided by some safety factor. That works well for steel, in which stress is calculated in a straightforward manner. However, the advent of reinforced concrete and the presence of a variety of loads prompted another design paradigm. In part because of the maturing of reliability analysis methods in the 1970s the limit-state design concept, sometimes called load and resistance factored design, became prominent in the 1980s. With this approach, the quintessential design equation reads

$$\phi \cdot M_{Capacity} \leq \gamma_{Wind} \cdot M_{Wind} + \gamma_{Snow} \cdot M_{Snow} \quad (1)$$

where M are bending moment values, ϕ is a safety coefficient on the capacity, and γ are safety coefficients on the loads. Reliability methods meant to calculate the probability of failure associated with Eq. (1) are presented elsewhere on this website. An informal and subjective view of the evolution of probabilistic design approaches is given in Figure 1, for now without further discussion.

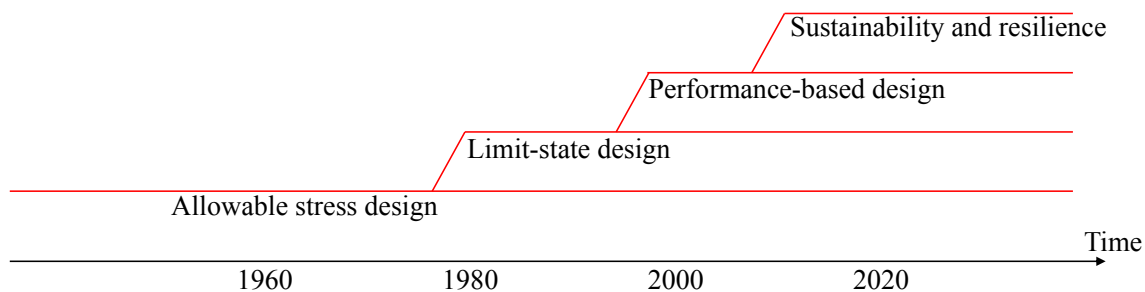


Figure 1: A timeline of design paradigms.