Quantifying Uncertainty in Infrastructure Studies

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Do you ever wonder, as you drive across a suspension bridge, whether anyone really ever checks the bridge's cables? Or what might happen if you are in a building when the ground beneath it starts to tremble during an earthquake? George Deodatis has made numerous contributions in the general field of probabilistic mechanics: the reliability and safety analysis of structures, risk assessment, and risk management of civil infrastructure systems, earthquake engineering, and hazards analysis.

One of his current research projects deals with the monitoring and prediction of the safety of aging suspension bridge cables, with New York City's Williamsburg Bridge as one of his models. He is using stochastic field theory to deal with the various uncertainties involved in the problem of estimating the strength of the thousands of wires (several of which can be broken) contained within a suspension cable. His results are already helping to assess the current safety and future reliability of suspension bridges around the world.

Deodatis is also studying the effect of climate change on the civil infrastructure. "This is a problem of truly major societal significance," he said. "For example, how is sea-level rise—in combination with hurricanes—going to affect densely built coastal megacities?" He is working on this challenging problem, which involves a wide range of difficult-to-quantify uncertainties, with the ultimate objective of estimating the consequences of climate change and suggesting a wide range of mitigation measures.

Another important application of stochastic field theory that Deodatis is working on has to do with soil liquefaction, a destructive phenomenon that occurs during earthquakes, causing major structural damage, and with bearing capacity of soils, another phenomenon with major impact for the behavior of a wide range of structures on relatively weaker soils. "We are hoping to account for the inherent uncertainty of the soil mass," said Deodatis. "Learning more about these phenomena should lead eventually to improved mitigation strategies."

Deodatis is currently finalizing a book with Cambridge University Press about "Simulation of Stochastic Processes and Fields" in which he develops the theoretical foundations as well as the corresponding simulation formulas for a broad array of stochastic processes and fields. There are numerous applications of these theories in various fields of engineering and applied science, including earthquake engineering, wind engineering, micro- and nano-mechanics, offshore engineering, environmental engineering, materials science, atmospheric science, oceanography, finance, and many others.

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