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International Doctoral Program in Civil and Environmental Engineering

SEMINAR

Research Activities and Future Perspectives on Long-Span Bridge Aeroelasticity

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Location:
UNIPG Campus of Engineering, Via G. Duranti, 93, Perugia, Aula Magna

Timetable:
June 19th 2024
3:00 p.m. (CET)

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Abstract

Fifty years have passed since the pioneering paper by Scanlan and Tomko ("Airfoil and bridge deck flutter derivatives", J. Eng. Mech. Div., ASCE, Vol. 97, Pt. 6, pp. 1717-1737, 1971) first proposed the successful modeling of flutter and buffeting for long-span bridges. This paper introduced the research field of bridge aeroelasticity. The model originates from the concept of Scanlan Derivative (SD), a set of empirically measured functions that physically describe the various features of the fluid-structure interaction od the bridge deck. The SD functions combined with the multi-mode approach provided the fundamentals that led to the study, design and construction of several long-span bridges around the world. Longer spans, however, necessitate the study of alternative solutions to increase structural reliability against wind loads. Furthermore, as the number of built bridges increases, the problems of long-term bridge maintenance and lifecycle operations become important. Finally, new designs of super long bridges are being considered with total spans reaching unprecedented lengths. This presentation examines the personal research experience in the field of bridge aeroelasticity of the author, by adapting and re-casting the SD modeling approach to solve two specific issues and to demonstrate its continued validity.First, the presentation describes recent derivations and an analytically based, numerical algorithm for "uncertainty" propagation and its effects on bridge structural analysis. Uncertainty is utilized to describe either a simplification in the empirical aeroelastic modeling (i.e., the SDs) or the quantification of experimental errors, for example associated with a wind-tunnel test. This study provides, by theoretical derivations, estimation of the stationary joint-probability distribution of the generalized bridge response, accounting for perturbations. The formulation includes, in particular, a random variable, which quantifies errors in the span-wise correlation of the buffeting deck load. Both flutter probability and buffeting response will be examined. A 1200m bridge example, modeled after the Golden Gate Bridge, and a 3000m bridge example, modeled after the Messina Strain Bridge, are used as benchmark structures Second, the problem of increasing structural reliability through bridge flutter control is considered. Even though several methods have been employed to increase the bridge flutter threshold (e.g., tuned-mass dampers, active or passive flaps, etc.), the use of gyroscopic devices has been recently proposed by the author as an active stabilizer. Results of a parametric study are discussed, demonstrating the stabilizer's performance on the above-described benchmark bridges within its practical operational range. The critical flutter velocity remarkably increases, if multi-unit gyroscopic devices are installed.Finally, the presentation will provide an opportunity to discuss personal, future avenues for the study of bridge aeroelasticity.

Luca Caracoglia is currently a Visiting Professor in the Department of Civil and Environmental Engineering at the University of Perugia in June 2024. His permanent position is Full Professor in the Department of Civil and Environmental Engineering of Northeastern University (NU), Boston, Massachusetts, USA, where he directs the "Wind Engineering Research Group". Luca Caracoglia's research and professional interests are in structural dynamics, random vibrations, fluid-structure interaction of civil engineering structures, nonlinear cable network dynamics, wind engineering, wind energy and wind-based energy harvesting systems. He has been author or co-author of 100+ peer-reviewed journal publications and book chapters and about 140 conference proceedings / presentations in these fields. Luca Caracoglia has taught a range of undergraduate and graduate courses spanning from Statics/Solid Mechanics to Wind Engineering. He earned the NSF-CAREER Award in 2009 and was named a Fellow ASCE in 2020. He holds leadership positions in wind engineering associations and has chaired significant workshops and colloquiums. Caracoglia serves as an Associate Editor for prestigious journals and is a member of multiple editorial boards. Additionally, he received two Full Professor accreditations from the Italian Ministry of Public Instruction University and Research (MIUR) in 2019: 1) Scientific Discipline ICAR 08/B3, Civil Engineering/Structural Design, 2) Scientific Discipline ICAR 08/B2, Civil Engineering/Structural Mechanics.

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