POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: AEROLASTICITY OF LONG SPAN BRIDGES

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	In the design of structures, wind-induced excitation is typically estimated by considering only synoptic winds, such as extratropical storms, and mesoscale tropical storms like hurricanes. However, non-synoptic winds, including thunderstorms and downbursts, can be extremely damaging in certain European regions. With the potential for their intensity to increase in the coming years due to global warming, these events could become increasingly destructive. The accurate modeling of wind-induced effects on structures requires the consideration of transient aerodynamics associated with the non-stationary features of these winds. Long-span bridges, situated at heights where the wind field induced by thunderstorms can be particularly intense, are highly susceptible to their impact. Therefore, it is crucial to enhance our understanding of the nature of thunderstorm downbursts and their transient effects on bridges through dedicated investigations. Within this context, this research aims to make advancements in three main areas: 1. Thunderstorm downburst modeling along linear horizontal domains: This involves introducing a model of the downburst-induced wind field along the bridge deck. A statistical characterization of the single and multi-point wind velocity will be provided based on the analysis of available anemometric data on existing

	monitored bridges. 2. Experimental assessment of transient bridge aerodynamics in wind tunnel: An experimental campaign will be conducted to establish reliable models for the transient aerodynamics of bridge decks. Initially, static wind tunnel tests will be carried out with a slowly-varying mean wind speed to derive the static coefficients under transient flow conditions. Subsequently, aeroelastic wind tunnel tests will be performed by applying harmonic or random motions to the sectional model, along with a slowly-varying mean wind speed. 3. Analysis of transient wind-induced structural response of long-span bridges: Numerical models for transient wind loads on deck sections will be evaluated and potentially improved. These loading conditions will then be applied to a full-bridge model to assess the implications of non-stationary wind input on bridge design, in comparison to standard approaches that rely on stationary wind conditions.
Methods and techniques that will be developed and used to carry out the research	The PhD candidate will have the responsibility of developing analytical and numerical models to accurately capture the aeroelastic forces acting on bridge decks. These models will incorporate non-linear aspects of aerodynamics and consider the non-synoptic characteristics of incoming turbulent wind. To validate these models and investigate the non-linear features of deck sections with different geometries, the candidate will conduct wind tunnel tests using sectional deck models and aeroelastic full bridge models. The recently implemented wind tunnel setup at Politecnico di Milano, equipped with a 3-degree-of-freedom dynamometric test rig, will be used for successful research on sectional models. The candidate's work will involve integrating the developed numerical models into existing in-house programs that simulate fluid-structure interaction, utilizing

	tools such as Matlab and Fortran. The focus will be on improving existing models and exploring new approaches and techniques that may not have been previously employed in wind engineering but have shown promise in other fields. In particular, the candidate will simulate the dependence of aeroelastic forces on the slowly varying angle of attack and mean wind speed using dynamic models with time-varying parameters, capable of capturing the non-linear and non-stationary characteristics of aeroelastic forces. Regarding the modeling of non-synoptic wind fields, the candidate will need to derive a time-varying power spectrum model that accounts for the non-stationary nature of wind velocity. This will involve determining time-varying characteristics and conducting stochastic simulations of multi-dimensional wind velocity fields based on measured data. Furthermore, the candidate will establish a framework for simulating random wind fields, focusing on the time-varying correlation and coherence between multiple points in space. Overall, the candidate's research will involve advancing existing numerical models, exploring innovative techniques, conducting experimental validations, and contributing to the understanding and simulation of non-linear and non-stationary wind effects for long span bridges.
Educational objectives	The PhD program offers a remarkable opportunity for candidates who are motivated and ambitious, possess proficiency in goal-oriented work, demonstrate good cooperation abilities, and excel in scientific writing and oral presentation skills. The main objective for the candidate is to contribute original research and advancements in the development and validation of numerical and experimental tools for simulating the aeroelastic response of bridges. This research will involve collaborating with renowned international experts, fostering valuable relationships, and working effectively within a high-level international research team. By engaging in this challenging research environment,

	the PhD candidate will acquire valuable skills, knowledge, and expertise, establishing themselves as an expert in the field of wind engineering and bridge design. They will be equipped to tackle complex problems and make significant contributions in their chosen area of specialization.
Job opportunities	The competence and expertise acquired through this research will open up various job opportunities primarily in the wind engineering field. These opportunities include positions in engineering companies, engineering and project management firms, as well as with operators and infrastructure managers who deal with wind-related aspects. Additionally, the acquired skills will be valuable for R&D departments of companies involved in road and railway infrastructure design. The knowledge and expertise in bridge aeroelastic response gained during the PhD program will be applicable to addressing the challenges faced in these industries. Furthermore, job prospects extend to national and international academic and non-academic institutions and organizations that are actively engaged in innovation, research, and technical development. These institutions and organizations often seek professionals with expertise in wind engineering and bridge design to contribute to their projects and initiatives. Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared to Master of Science holders in the same field.
Composition of the research group	3 Full Professors 3 Associated Professors 2 Assistant Professors 3 PhD Students
Name of the research directors	Proff. Tommaso Argentini, Daniele Rocchi

Contacts
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For questions about scholarship/support, please contact phd-dmec@polimi.it.

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of euro 5.707,13.

Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 700 euro/month- net amount).

Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.