



PhD in ARCHITETTURA, INGEGNERIA DELLE COSTRUZIONI E AMBIENTE COSTRUITO / ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING - 39th cycle

PNRR 118 PNRR Research Field: NON-DESTRUCTIVE METHODOLOGIES FOR THE ASSESSMENT OF POST-TENSIONED REINFORCED CONCRETE BRIDGES

Monthly net income of PhDscholarship (max 36 months)

€ 1275.0

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

Italian transport infrastructures show severe issues. Many bridges and viaducts date back to post World War II and their characteristics are far away from those required by modern design codes. They can be subjected to natural hazards not considered in the original design. Design traffic loads may be significantly lower than those prescribed by current norms. In addition, material degradation over time can lead to a decrease in performance of structural elements due to poor maintenance or lack of effective inspections.

This situation is particularly relevant for **Post-Tensioned (PT) prestressed concrete bridges**, where the post-tensioning tendons are encased in metal or plastic ducts under the concrete cover, making visual inspections unable to investigate their state of conservation. PT elements of bridges, including especially those built in the 1960s/70s, are sensitive to degradation phenomena, and in particular corrosion of steel strands can reduce the resistance of the structure and cause sudden collapses. These dangerous situations are mainly generated by defects in grout injections of the ducts which represent preferential areas for the initiation of strand corrosion. Notable failures of PT bridges have indeed highlighted their vulnerability to hidden defects.



	<p>The fragility of PT bridges has been highlighted in the 'Guidelines for risk classification and management, safety assessment and monitoring of existing bridges' (by the Ministry of Infrastructures and Sustainable Mobility), which emphasize the need of evaluating the condition of PT systems by investigating the integrity of the ducts and the corrosion of steel strands. The Guidelines define only in a general way the investigations that can be pursued, without providing a well established method. Moreover, it is not possible to take advantage of the established knowledge as the usual methodologies for ordinary RC structures are not workable for PT elements.</p> <p>This research aims at assessing non-destructive (ND) techniques for the inspection of PT bridges which include the analysis of the main geometrical, mechanical and state of conservation characteristics necessary for a reliable assessment of the level of safety. Viable ND techniques for the identification of tendon routing, localization and quantification of defects, evaluation of the mechanical properties of tendons, and evaluation of prestressing in concrete will be identified, characterized and ranked.</p> <p>This research, addressing the improvement of quality and sustainability of road infrastructures, is in line with PNRR Mission 3 Infrastructures for sustainable mobility, component M3C1.2 Road safety 4.0, Reform 2.2 Implementation of the Guidelines for risk classification and management, the safety assessment and monitoring of existing bridges.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>To give bridge owners confidence that their PT bridge stock is in a good and safe condition it is essential to implement effective inspection and monitoring regimes. Visual inspections, though may not give warning of imminent collapse, are useful to identify defects relevant to the PT system that provide symptom regarding the system itself. Starting from the data collected in visual inspections, other techniques must be implemented to evaluate the conditions of steel tendons hidden by the ducts. The first task will consist in survey of existing ND techniques, either already identified by modern bridge</p>



inspection guidelines or used in other industrial fields, and the identification of viable methods for the assessment of PT systems, considering the following tasks: identification of cable routing, localization and quantification of defects of grout (e.g., compromised grout, voids, water infiltration) and tendons (e.g., strand corrosion, loss of section, strand breakage), evaluation of loss of post-tensioning in concrete. The second task will consist in the characterization of the identified tests/instruments. To assess the reliability of a methodology, it is necessary to test it on a known specimen. Therefore, lab tests will be taken into account.

ND techniques will be assessed in experimental campaigns performed both at the Materials Testing Laboratory of Politecnico and at the Department of Civil and Environmental Engineering of the University of Missouri. Data will be collected to describe the uncertainties of the chosen techniques, taking into account both the uncertainties related to the instrument/technology employed, and the boundary condition related to the way/the ambient in which the test is carried out. An appropriate number of tests shall be performed in order to evaluate statistically the uncertainties and to finally obtain a probabilistic description of the output.

The assessed ND techniques will be then ranked based on the accuracy, the ease of use, the cost, and the invasiveness; a specific weight will be assigned to each category, and finally a weighted sum model (WSM) will be proposed. The goal is to provide bridge owners and inspectors with a tool which can assist in the selection of the optimal ND technology available to detect a particular strand or grout defect accounting for different factors. Eventually, the tool will be tested on a set of case study PT concrete bridges representative of the existing Italian infrastructure asset.

The program includes an internship of at least 6 months at the Department of Civil and Environmental Engineering, University of Missouri, where the PhD student will be involved in studies on the reliability of NDE technologies and perform laboratory tests on ND techniques.



Educational objectives	<p>The PhD intends to train the researcher with advanced knowledge on risk assessment, classification, verification, control and monitoring of civil engineering structures, addressing the topical issue of the improvement of quality and sustainability of road infrastructures.</p> <p>The PhD programme will also develop team working attitude and will create opportunities for collaborations with national and international research centers, and with the operators of the main national road networks.</p> <p>For further information: FABRE Consortium - Research consortium for the evaluation and monitoring of bridges, viaducts and other structures: https://www.consorziofabre.it/ Prof. Glenn Washer (internship supervisor at University of Missouri): https://engineering.missouri.edu/faculty/glenn-washer/</p>
Job opportunities	<ul style="list-style-type: none"> •Bridge Inspector and Bridge Tunnel Maintenance Manager in Infrastructure Operators. •Researcher in research centers or universities.
Composition of the research group	0 Full Professors 2 Associated Professors 2 Assistant Professors 1 PhD Students
Name of the research directors	Prof. Virginio Quaglini and Sara Cattaneo

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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	637.5 €
By number of months	6



National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	
By number of months at the company	0
Institution or company where the candidate will spend the period abroad (name and brief description)	Department of Civil and Environmental Engineering, University of Missouri, U.S. - https://engineering.missouri.edu/faculty/glenn-washer/
By number of months abroad	6

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

Additional support:

Budget for the research activity (only for positions supported by scholarship): total amount Euro 5197.60 per student.

In detail:

- 1st year Euro 1732.53
- 2nd year Euro 1732.53
- 3rd year Euro 1732.53

Additional information about the organization and regulations of ABC-PhD programme can be found in the Regulations for the 39th Cycle of ABC-PhD: download is available at link: <https://www.dottorato.polimi.it/corsi-di-dottorato/architettura/architettura-ingegneria-delle-costruzioni-e-ambiente-costruito>

Additional information about ABC department and ABC-PhD programme: available at link: <https://www.dabc.polimi.it/>

Desk availability: The ABC department provides non-permanent desks to be temporarily booked in common PhD rooms.

This scholarship is funded by the PNRR national programme under the research line on "Generic PNRR topics" in D.M. 118. This means that the owner of the position will be obliged to submit periodical reports about her/his activity.