Abstract

The management of existing civil infrastructure, particularly bridges, is a complex and critical challenge in the field of civil engineering. Bridge deterioration has become a pressing issue due to factors such as increased traffic loads, environmental impacts, use of de-icing salts, limited maintenance programs, and poor-quality structural materials. As a result, bridges can exhibit both structural deficiencies and functional obsolescence, highlighting the importance of their thorough assessment in modern civil engineering. Structural assessment is a multi-stage process that involves refining analytical models, planning diagnostic campaigns, and gaining a comprehensive understanding. However, this process is often constrained by resource limitations, low accessibility, and the need for accurate parameter estimation. Consequently, a systematic and rational approach is essential to address the technical and economic challenges associated with structural assessment. While several countries have developed safety assessment guidelines based on different formats, there is a notable gap in terms of a suitable framework to establish reliable and feasible techniques to achieve a predetermined and acceptable level of knowledge. In order to limit this gap, the present research defined a robust and practical framework for the structural assessment of existing prestressed concrete (PC) bridges. To accomplish this objective, a comprehensive experimental program was undertaken as part of the BRIDGE|50 research project, focusing on full-scale testing of PC bridge girders removed after 50 years of service. The aim of this program was to provide extensive data on the performance of aging girders, facilitating informed decision-making processes for bridge management agencies.

This thesis deals with several key areas of investigation in the context of the structural assessment of existing PC bridges. Firstly, a thorough durability assessment was conducted, employing visual inspection and non-destructive testing (NDT) techniques. These techniques, including half-cell potential mapping, concrete resistivity measurement, carbonation depth evaluation, and corrosion current density measurements, effectively assessed the extent and rate of deterioration and provided valuable insight into the structural condition of the bridges. The mechanical characterization of the materials was carried out using destructive methods. For concrete's mechanical properties, an integrated approach with both destructive and NDT techniques has been also used, allowing for the investigation of larger areas and reducing material uncertainties in a cost-effective manner. For prestress loss estimates, several methods have been used involving destructive tests, NDT, and analytical models. A valuable procedure has been proposed to estimate the prestress loss for girders still in service, based on the so-called saw-cut method. In addition, a comprehensive analysis of the structural behavior was carried out through full-scale load tests on the PC girders. These tests included different levels of damage and loading configurations, allowing a detailed examination of the structural behavior under different scenarios. By inducing different loading conditions to stimulate different resistance mechanisms, the resulting load-deflection curves, midspan strains, and failure modes were thoroughly analyzed. The outcomes of these analyses provided a comprehensive insight into the performance of existing PC bridges under realistic conditions. Finally, a comparative analysis of different safety formats was carried out within a multi-level framework, ranging from deterministic to probabilistic approaches. By integrating these safety formats into the assessment process, more informed decisions could be made based on the research findings.

In conclusion, this research highlights the urgent need for a robust and practical framework for the structural assessment of existing PC bridges. The experimental program undertaken as part of this study provides valuable insight

into the performance and condition of aging bridge girders. By incorporating NDT, characterization of mechanical properties, and comprehensive analysis of structural behavior, the research presents a holistic approach to bridge assessment, thereby aiding in the development of effective maintenance and management strategies for existing PC bridges.