



Article

Condition Assessment of Reinforced Concrete Bridges: Current Practice and Research Challenges

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Abstract: One quarter of bridges in Canada and the United States need repair. The present study provides a critical overview of the state-of-the-art existing condition assessment techniques for reinforced concrete bridges, with an emphasis on current practice in North America. The techniques were classified into five categories, including visual inspection, load testing, non-destructive evaluation, structural health monitoring, and finite element modelling. The potential applications of these technologies are discussed and compared, highlighting their primary advantages and limitations. The review revealed that quantitative assessment could be effectively achieved using several complementary technologies. It is shown that there is need for concerted research efforts to achieve automated data collection and interpretation analyses. Also, the configuration of monitoring systems was found to be paramount in effectively assessing bridge performance parameters of interest. The study suggests appropriate investigation methods for some bridge deterioration mechanisms. Knowledge gaps and challenges in this field are outlined in order to motivate further research and development of these technologies.

Keywords: concrete bridges; deterioration; condition assessment; visual inspection; load testing; non-destructive evaluation; structural health monitoring; finite element modelling

1. Introduction

Bridge failures can be catastrophic, both in terms of human life and economic loss. According to the Canadian infrastructure report card (2016), 26% of bridges are in fair, poor or very poor condition, and US \$50 billion needs to be invested for bridge replacement and maintenance. Likewise, about 25% of bridges in the USA are either structurally deficient or functionally obsolete, and \$70.9 billion is needed to address their maintenance [1]. Reinforced concrete (RC) bridges often deteriorate due to ageing, materials and construction defects, exposure to aggressive environments, lack of ductility, and excessive loads. The distinction among their major degradation causes is purely qualitative since such mechanisms can act in synergy. Different deterioration processes lead to different types of defects, which represent the main challenge in bridge inspection programmes. In addition, fire is one of the most severe hazards to which RC bridges may be subjected during its service life. Bridge management systems (BMSs) have been developed to assist decision makers in maximizing the safety, serviceability, and functionality of bridges within available budgets. The basic components of a BMS are illustrated in Figure 1. The architecture of a typical BMS consists of a database, condition and structural assessment modules, a deterioration prediction module, a lifecycle cost module, and a maintenance optimization module. The database stores inventory and appraisal data. The condition assessment module evaluates the existing health condition of the bridge(s). The deterioration prediction module estimates the future condition of bridge components. The life-cycle cost module calculates agency and user costs

Concrete Structures Condition Assessment Guidelines

Eugene Zeller



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Life-Cycle Civil Engineering: Innovation, Theory and Practice Airong Chen,Xin Ruan,Dan M. Frangopol,2021-02-26 Life Cycle Civil Engineering Innovation Theory and Practice contains the lectures and papers presented at IALCCE2020 the Seventh International Symposium on Life Cycle Civil Engineering held in Shanghai China October 27 30 2020 It consists of a book of extended abstracts and a multimedia device containing the full papers of 230 contributions including the Fazlur R Khan lecture eight keynote lectures and 221 technical papers from all over the world All major aspects of life cycle engineering are addressed with special emphasis on life cycle design assessment maintenance and management of structures and infrastructure systems under various deterioration mechanisms due to various environmental hazards It is expected that the proceedings of IALCCE2020 will serve as a valuable reference to anyone interested in life cycle of civil infrastructure systems including students researchers engineers and practitioners from all areas of engineering and industry **Ninth International Symposium on Environmental Degradation of Materials in Nuclear Power Systems** Steve Bruemmer,Peter Ford,Gary Was,2013-10-18 This collection presents an exchange of ideas among scientists and engineers about the economic and safety concerns surrounding environmentally induced materials problems which lead to nuclear power plant outages Scientists and engineers concerned with the environmental degradation processes corrosion mechanical and radiation effects present their latest results on such topics as life extension relicensing and materials problems associated with spent fuel storage and radioactive waste disposal This collection will be of interest to utility engineers reactor vendor engineers plant architect engineers researchers concerned with materials degradation and consultants involved in design construction and operation of water reactors **ACI Manual of Concrete Practice** American Concrete Institute,2002 **NEHRP Commentary on the Guidelines for the Seismic Rehabilitation of Buildings** Eugene Zeller,2000-06 This document from the National Earthquake Hazards Reduction Program NEHRP was prepared for the Building Seismic Safety Council BSSC with funding from the Federal Emergency Management Agency FEMA It provides commentary on the NEHRP Guidelines for the Seismic Rehabilitation of Buildings It contains systematic guidance enabling design professionals to formulate effective reliable rehabilitation approaches that will limit the expected earthquake damage to a specified range for a specified level of ground shaking This kind of guidance applicable to all types of existing buildings in all parts of the country has never existed before Illustrated **Selected Proceedings of the 2nd International Engineering Research Symposium; IERS 2024; 14 Aug; Colombo, Sri Lanka** T. Nilanthi Fernando,Manjula Siriwardhana,Ranjith Dissanayake,Meththika Vithanage,Jayathu G. Samarawickrama,Pradeep Gajanayake,2025-03-03 This book presents selected peer reviewed articles from the 2nd International Engineering Research Symposium IERS 2024 held at Colombo in Sri Lanka under the theme of Engineering Innovations for Economic Transformation It highlights the latest advancements in engineering research innovations and technological principles aimed at driving economic changes and improvements within society and the industry IERS2024

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Case Studies of Rehabilitation, Repair, Retrofitting, and Strengthening of Structures Mourad M. Bakhoun, 2010

Guide for Evaluation of Concrete Structures Prior to Rehabilitation ACI Committee 364, 1993

Non-destructive Testing of Wisconsin Highway Bridges Alireza Ghorbanpoor, Neal Benish, 2005 *Overview of Industry Guidance on Concrete Condition Assessment and Concrete Repair for Use Prior to Coating*, 2000 This Special Publication SP introduces a brief overview of concrete repair guidance offered by the American Concrete Institute ACI International the International Concrete Repair Institute ICRI the American Concrete Pavement Association ACPA the Aberdeen Group the Portland Cement Association PCA and work by authors considered experts in the field of concrete repair The publication is divided into two parts Part I *Failure, Distress and Repair of Concrete Structures* N. Delatte, 2009-11-24 Many concrete structures around the world have reached or exceeded their design life and are showing signs of deteriorating Any concrete structure which has deteriorated or has sustained damage is a potential hazard Guide for Nondestructive Evaluation Methods for Condition Assessment, Repair, and Performance Monitoring of Concrete Structures International Concrete Repair Institute, 2009 Failure, Distress and Repair of Concrete Structures Norb Delatte, 2009-10-26

Understanding and recognising failure mechanisms in concrete is a fundamental pre requisite to determining the type of repair or whether a repair is feasible This title provides a review of concrete deterioration and damage as well as looking at the problem of defects in concrete It also discusses condition assessment and repair techniques Part one discusses failure mechanisms in concrete and covers topics such as causes and mechanisms of deterioration in reinforced concrete types of damage in concrete structures types and causes of cracking and condition assessment of concrete structures Part two reviews the repair of concrete structures with coverage of themes such as standards and guidelines for repairing concrete structures methods of crack repair repair materials bonded concrete overlays repairing and retrofitting concrete structures with fiber reinforced polymers patching deteriorated concrete structures and durability of repaired concrete With its distinguished editor and international team of contributors Failure and repair of concrete structures is a standard reference for civil engineers architects and anyone working in the construction sector as well as those concerned with ensuring the safety of concrete structures Provides a review of concrete deterioration and damage Discusses condition assessment and repair techniques standards and guidelines *NEHRP Guidelines for the Seismic Rehabilitation of Buildings*, 1997

Structural Condition Assessment Robert T. Ratay, 2005-01-17 In Structural Condition Assessment editor in chief Robert T Ratay gathers together the leading people in the field to produce the first unified resource on all aspects of structural condition assessment for strength serviceability restoration adaptive reuse code compliance and vulnerability

Organized by the four main stages of a structural evaluation this book provides an introduction to structural deterioration and its consequences the business and legal aspects of conducting an evaluation initial survey and evaluation techniques for various structures and specific tests for five of the most common structural materials concrete steel masonry timber and fabric

Assessment and Renovation of Concrete Structures Ted Kay,1992 Part of the Concrete Design and Construction series this text considers the assessment and renovation of concrete structures It covers such areas as deterioration process testing techniques interpretation of results repair and renovation techniques and contract documents

Concrete International,2004 Guideline for Structural Condition Assessment of Existing Buildings American Society of Civil Engineers,Structural Engineering Institute,2000-01 Changing economic conditions concern for historic preservation emphasis on fully utilizing conveniently located structures space shortages and increasing cost of materials and products used in the construction of new buildings have resulted in a need to evaluate and more fully utilize the existing building inventory To this end this revision of the ASCE Standard Guideline for Structural Condition Assessment of Existing Buildings a replacement of ASCE 11 90 provides the design community with guidelines for assessing the structural conditions of existing buildings constructed of combinations of material including concrete masonry metals and wood It consists of an overview of preliminary and detailed assessment procedures of materials properties and test methods and of evaluation procedures for various physical conditions of the structure This information has been compiled and subjected to a consensus review and approved by the ASCE Standards Committee on Structural Condition to provide a much needed resource standards on building condition assessment for selected materials and for other areas related to the structural performance of buildings Professional engineers building owners and regulatory officials will find this Standard Guideline invaluable

Handbook of Corrosion Engineering 2/E Pierre R. Roberge,2012-07-10 This comprehensive resource covers all aspects of corrosion damage including detection monitoring prevention and control Back cover

Repair and Renovation of Concrete Structures Ravindra K. Dhir,M. Roderick Jones,Li Zheng,2005 Preface Introduction Organising Committee Scientific and Technical Committee Collaborating Institutions Sponsoring Organisations with Exhibition Exhibiting Organisations Supporting Institutions Opening Paper Getting it Right From Testing Through Diagnosis to Lasting Repair

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 Structures Re alkalisation of Carbonated Concrete by Alkalline Solutions Absorption and Diffusion Mechanisms External
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 Structures Effect of Temperature on the Durability of Systems of Strengthening of Concrete Structures Axial Compressive
 Strength of Reinforced Concrete Columns Wrapped with Fibre Reinforced Polymers FRP Efficiency of Hybrid FRP Sheets in
 Strengthening Concrete Beams Embedded Fibre Bragg Grating Sensors for Monitoring the Health of Concrete Structures
 Performances of Bonded An Companion Guide to the ASME Boiler & Pressure Vessel Code K. R. Rao,2006 This is Volume
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impact and dynamic loads functionality and operability criteria fluids pipe vibration stress intensification factors stress indices and flexibility factors code design and evaluation for cyclic loading and bolted flange joints and connections

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