Durability Of Cfrp Strengthened Concrete Structures Under

Given the increasing use of fibre-reinforced polymer (FRP) composites in structural civil engineering, there is a vital need for critical information related to the overall durability and performance of these new materials under harsh and changing conditions. Durability of composites for civil and structural applications provides a thorough overview of key aspects of the durability of FRP composites for designers and practising engineers. Part one discusses general aspects of composite durability. Chapters examine mechanisms of degradation such as moisture, aqueous solutions, UV radiation, temperature, fatigue and wear. Part two then discusses ways of using FRP composites, including strengthening and rehabilitating existing structures with FRP composites, and monitoring techniques such as structural health monitoring. Durability of composites for civil and structural applications provides practising engineers, decision makers and students with a useful and fundamental guide to the use of FRP composites within civil and structural engineering. Provides a thorough overview of key aspects of the durability of composites Examines mechanisms of degradation such as aqueous solutions, moisture, fatigue and wear Discusses ways of using FRP composites, including strengthening and rehabilitating existing structures

"This research investigated the durability of carbon-fiber-reinforced polymer composites (CRFP) used for shear strengthening reinforced concrete deck girders. Large beams were used to avoid accounting for size effects in the data analysis. The effort included determining the role of freeze-thaw, moisture, and fatigue of structural performance and developing analytical design procedures that account for durability"--Technical report documentation page.

Carbon fiber-reinforced polymers (CFRP) have been widely used as externally epoxy-bonded reinforcement for repair and retrofit of existing concrete structures. As the use of CFRP in construction increases, it is essential to consider the long term behavior. In this study, concrete specimens with externally bonded CFRP composite systems were exposed to various accelerated ageing environments: different elevated temperature water immersion, varying relative humidity exposure, real-time solar exposure, pressurized hygrothermal exposure, and fatigue loading. Three-point loading test and direct tension test were used to evaluate the flexural and tensile strength of CFRP specimens. This research recommends that the durability strength reduction factor be defined as the ratio of the flexural strength of a test specimen after exposure for 60 days at 60C to the strength of a control specimen at the initiation of exposure. Test specimens, exposure environments, testing procedures, and field application environments are selected to assure uniform reporting, testing and application of durability strength reduction factors. Two exposure environments are recommended for design, wet and air. Water can diffuse through concrete and accumulate on the epoxy/concrete interface in a wet environment and is the default condition for design. An air environment precludes water accumulation but requires engineering design and validation to guarantee compliance. The resulting durability strength reduction factor may be used to (a) calculate the reduced strength for environmental exposure, (b) qualify a specific CFRP system, (c) compare durability reduction factors to those provided by system suppliers, and (d) confirm compliance with project specifications.

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Behavior of Carbon Fiber Reinforced Polymer (CFRP) Anchors Strengthening Reinforced Concrete Structures

Durability of Carbon Fiber Reinforced Polymer (CFRP) Strengthening Systems Used to Repair Corrosion Damage in Reinforced Concrete

Properties and Applications

Composite Materials for Bridge Repair in Cold Region

Durability of Carbon Fiber Reinforced Polymer (CFRP) Repair/strengthening Concrete Beams
Proceedings of the First International Conference (CDCC'98) Sherbrooke (Quebec) Canada, August 5-7, 1998
Abstract: The use of carbon fiber reinforced polymers (CFRP) into the repair and retrofitting of concrete structures has been growing exponentially over the past two decades worldwide. The composite offers a superior strength- to- weight ratio as well as good durability in various service environments. The proper implementation of CFRP system involves a clean concrete surface, a powerful adhesive, such as epoxy resins together with compatible CFRP. However, one of the limiting factors towards the widespread of CFRP systems is attributed to its low resistance to elevated temperature and fire. Hence, efforts have been exerted to better understand and quantify this negative effect and to provide external protection for the system in order to alleviate the negative of impact of elevated temperature. This study focuses on assessing the impact of elevated temperature on the flexural strength of externally bonded CFRP with and without protection. Two sets of plain concrete beams have been prepared without protection and with a ready-to-use cementitious protective. All beams were subjected to temperature degrees of 70, 120 and 180 °C for 1, 2, 4 and 8 hours in a furnace. The flexural strength and mode of failure have been assessed for each set. The results of this work demonstrate the CFRP strengthened beams experienced a drastic loss in strength upon exposure to elevated temperature. The extent of the drop in strength varied according to degree of exposure as well as duration. On the whole, CFRP unprotected beams were able to restore 40% of the flexural strength at 70 °C, while the CFRP strengthened protected beams restored 20% of the flexural strength of the CFRP strengthened beams. At exposure of 120 °C the CFRP strengthened beams showed increase in the flexural strength of 40% over unstrengthened unprotected beams. The CFRP strengthened protected beams surpassed the flexural strength of the CFRP strengthened beams at 120 °C by 20%. At exposure of 180 °C, the CFRP strengthened protected and unprotected beams failed to restore the lost flexural strength for the four and eight hours of exposure. This was followed by the appearance of the normal flexural crack on all the beams. Yet, the separation of the CFRP laminates from the concrete surface were noticed only at exposure to temperatures of 120 and 180 °C. The preliminary cost of the CFRP strengthened unprotected was estimated as 90% higher than the unstrengthened unprotected beams and the CFRP strengthened protected assessed as 16% higher than the CFRP strengthened unprotected. The results unveiled the ability of the CFRP strengthened beams to enhance the flexural strength upon exposure to elevated temperature along with the ability of the fire protection system to further improve this strength. Future work should be resumed to investigate wider sets of composites, various temperatures schemes, long term properties as well as applying the system to steel reinforced beams. It is also recommended to investigate the cooling effect on the performance of the strengthened and protected beams.
Fiber Reinforced Polymer (FRP) systems have gained much popularity as a method for reinforcing existing concrete structures. However a variety of sudden failure methods, such as debonding, delamination, and creep rupture have led to the development of code limitations on the strength that an FRP system can be considered to provide. The uncertainty brought on by the failure methods mentioned above has become the topic of much research. Researchers have proposed fracture and strength based methods to predict debonding. However, there are many environmental and durability issues that have not been considered in these prediction. These uncertainties make FRP strengthened concrete beams a good candidate for a health monitoring system. In this a paper a detailed look at current methods of predicting debonding is presented. Additionally, effects that the environment and durability have on debonding are presented. Finally, monitoring systems for FRP strengthened concrete beams are discussed. Two monitoring schemes are proposed.
The Concrete Solutions series of International Conferences on Concrete Repair began in 2003, with a conference held in St. Malo, France in association with INSA Rennes, followed by the second conference in 2006 (with INSA again, at St. Malo, France), and the third conference in 2009 (in Padova and Venice, in association with the University of Pado
This research provides a methodology for evaluation of durability related strength loss of bonded carbon fiber reinforced polymer (CFRP) systems applied to concrete beams. The report addresses test methods to establish a durability strength reduction factor, identification of corresponding field exposure conditions affecting durability, and suggestions for the application of the durability strength reduction factor for design of field applications. The durability strength reduction factor is a measure of the loss in strength over time due to environmental exposure. It is defined as the ratio of the flexural strength of a 4 in. x 4 in. x 14 in. concrete beam reinforced with CFRP exposed at 140°F and submerged in water or 100% relative humidity for 60 days to the flexural strength of a control specimen. The resulting durability strength reduction factor may be used to evaluate CFRP system performance. Two field environments are suggested: Wet and Air. In a Wet environment water accumulates at the bond surface. This is the default condition and corresponds to test results in submerged water at 140°F for 60 days. An Air environment allows drying between wetting episodes so water cannot accumulate on the bond surface. This condition corresponds to test results in 100% relative humidity at 140°F for 60 days.
Flexural Mechanical Durability of Concrete Beams Strengthened by Externally Bonded Carbon Fiber Reinforced Polymer Sheets
ACIC 2004
Proceedings of ASMA-2021 (Volume 3)
Durability of CFRP Strengthened RC Elements in Severe Environments
Proceedings of the 2nd International Conference on FRP Composites in Civil Engineering - CICE 2004, 8-10 December 2004, Adelaide, Australia
Qualitätssicherung bei Stahlbetonsanierungen mit aufgeklebten CFK-Lamellen
Following the success of ACIC 2002, this is the 2nd International Conference focusing on the application and further exploitation of advanced composites in construction held at the University

of Surrey in April 2004. With over 100 delegates the conference brought together practicing engineers, asset managers, researchers and representatives of regulatory bodies to promote the active exchange of scientific and technical information on the rapidly changing scene of advanced composites in construction. The aim of the conference was to encourage the presentation of new concepts, techniques and case studies, which will lead to greater exploitation of advanced polymer composites and FRP materials for the civil engineering infrastructure, rehabilitation and renewal.

Bridge Safety, Maintenance, Management, Life-Cycle, Resilience and Sustainability contains lectures and papers presented at the Eleventh International Conference on Bridge Maintenance, Safety and Management (IABMAS 2022, Barcelona, Spain, 11–15 July, 2022). This e-book contains the full papers of 322 contributions presented at IABMAS 2022, including the T.Y. Lin Lecture, 4 Keynote Lectures, and 317 technical papers from 36 countries all around the world. The contributions deal with the state-of-the-art as well as emerging concepts and innovative applications related to the main aspects of safety, maintenance, management, life-cycle, resilience, sustainability and technological innovations of bridges. Major topics include: advanced bridge design, construction and maintenance approaches, safety, reliability and risk evaluation, life-cycle management, life-cycle, resilience, sustainability, standardization, analytical models, bridge management systems, service life prediction, structural health monitoring, non-destructive testing and field testing, robustness and redundancy, durability enhancement, repair and rehabilitation, fatigue and corrosion, extreme loads, needs of bridge owners, whole life costing and investment for the future, financial planning and application of information and computer technology, big data analysis and artificial intelligence for bridges, among others. This volume provides both an up-to-date overview of the field of bridge engineering and significant contributions to the process of making more rational decisions on bridge safety, maintenance, management, life-cycle, resilience and sustainability of bridges for the purpose of enhancing the welfare of society. The volume serves as a valuable reference to all concerned with and/or involved in bridge structure and infrastructure systems, including students, researchers and practitioners from all areas of bridge engineering.

Many studies have investigated the use of carbon fiber reinforced polymer(CFRP) wraps to strengthen structural members, but there is limited literature on the application of presaturated CFRP wraps on reinforced concrete members. The main objective of this research is to study the long-term effectiveness of presaturated CFRP wraps in preventing corrosion of reinforced concrete specimens in severe environments. This paper presents numerical and experimental studies that were conducted to determine whether CFRP presaturated wraps provide a barrier against the ingress of chloride and permeability of water into concrete and thereby decelerate the corrosion process. The results show that the presaturated CFRP laminates, wrapped on high strength and normal strength concrete, provide a stronger barrier against chloride ingress and water permeability than the regular CFRP and control specimens without CFRP. A finite element model was validated with the experimental results, and an extensive parametric study on a typical Texas Department of Transportation (TxDOT) bridge column was conducted to identify the deterioration level of a CFRP-wrapped column in coastal environments. The results suggested that both regular CFRP and presaturated CFRP wrapped concrete columns reduce the clear cover and can be used to assess the long term durability of CFRP-wrapped concrete structures.

Long-term durability of surface-bonded carbon fiber-reinforced polymer (CFRP) for shear strengthening of reinforced concrete (RC) bridge members remains uncertain due to the limited field experience with these materials. This paper provides experimental results from the testing of full-scale RC bridge girder specimens after exposure to prolonged environmental exposure and combined action of freeze-thaw + repeated service loads. CFRP shear contributions seen in experimental results were estimated using a refined base capacity prediction (Response-2000) and compared to predicted CFRP shear contributions (ACI-440). The IT specimens did not exhibit strength reductions due to moisture exposure, instead the presence of continuous water exposure for the relatively young concrete caused higher concrete tensile properties resulting in increased bond strength. Previous research showed CFRP strengthened T specimens with freeze-thaw exposure exhibited lower shear capacity than similar unexposed CFRP strengthened T specimen. But the current research demonstrated that if the beam is well protected against moisture infiltration at the strip termination, the beam will be less susceptible to freeze-thaw bond deterioration. The orientations of specimens during repair and during exposure are important considerations for environmental durability. The CFRP strip terminations should be focused on during installation to insure well and perhaps extra saturation even past the CFRP material to limit moisture infiltration along this edge.

Proceedings of Fatigue Durability India 2019

Concrete Solutions 2011

Proceedings of the Eleventh International Conference on Bridge Maintenance, Safety and Management (IABMAS 2022), Barcelona, Spain, July 11-15, 2022

Freeze-thaw Durability of Reinforced Concrete Deck Girders Strengthened for Shear with Surface-bonded Carbon Fiber-reinforced Polymer

Durability of Composites for Civil Structural Applications

Response of Carbon Fiber Reinforced Polymers Strengthened Beams to Elevated Temperature

Externally bonded CFRP composite plates showed a great potential in the area of structural rehabilitation, and impressive applications have been reported. However, there are heightened concerns related to the overall durability under harsh environmental conditions. In aggressive environments, CFRP retrofitted systems are subjected to moisture, salts, ultraviolet radiations and high temperatures, which not only causing steel to corrode and concrete to deteriorate, but it may degraded the adhesive bond, hence limiting the strength of the retrofitted system. This is evident, since, at best, an insufficient bond renders the external reinforcement as ineffective as it is the mean to transfer stresses between the adherents. This study intends to examine the durability of the adhesive bond under accelerated laboratory conditions that mimic harsh environmental conditions, and under severe real-life environments that are prevalent at the Middle East countries, particularly at the Dead Sea and Aqaba regions of Jordan.

This volume highlights the latest advances, innovations, and applications in the field of FRP composites and structures, as presented by leading international researchers and engineers at the 10th International Conference on Fibre-Reinforced Polymer (FRP) Composites in Civil Engineering (CICE), held in Istanbul, Turkey on December 8-10, 2021. It covers a diverse range of topics such as All FRP structures; Bond and interfacial stresses; Concrete-filled FRP tubular members; Concrete structures reinforced or pre-stressed with FRP; Confinement; Design issues/guidelines; Durability and long-term performance; Fire, impact and blast loading; FRP as internal reinforcement; Hybrid structures of FRP and other materials; Materials and products; Seismic retrofit of structures; Strengthening of concrete, steel, masonry and timber structures; and Testing. The contributions, which were

selected by means of a rigorous international peer-review process, present a wealth of exciting ideas that will open novel research directions and foster multidisciplinary collaboration among different specialists.

Results of tensile tests on FRP coupons indicate that both epoxy and polyurethane FRP systems do not degrade significantly under environmental exposure. However, flexural tests on the FRP strengthened concrete beams indicate that bond between FRP and concrete shows significant degradation, especially for aqueous exposure. Moreover, a protective coating suppresses the measured degradation. Also, experimental load-displacement curves for control beams show excellent agreement with numerical load-displacement curves obtained using the proposed bond model. Finally, a bond-slip model is predicted for concrete leachate conditioned beams by matching load-displacement curves for those beams with numerical load-displacement curves.

Maintenance, Safety, Risk, Management and Life-Cycle Performance of Bridges contains lectures and papers presented at the Ninth International Conference on Bridge Maintenance, Safety and Management (IABMAS 2018), held in Melbourne, Australia, 9-13 July 2018. This volume consists of a book of extended abstracts and a USB card containing the full papers of 393 contributions presented at IABMAS 2018, including the T.Y. Lin Lecture, 10 Keynote Lectures, and 382 technical papers from 40 countries. The contributions presented at IABMAS 2018 deal with the state of the art as well as emerging concepts and innovative applications related to the main aspects of bridge maintenance, safety, risk, management and life-cycle performance. Major topics include: new design methods, bridge codes, heavy vehicle and load models, bridge management systems, prediction of future traffic models, service life prediction, residual service life, sustainability and life-cycle assessments, maintenance strategies, bridge diagnostics, health monitoring, non-destructive testing, field testing, safety and serviceability, assessment and evaluation, damage identification, deterioration modelling, repair and retrofitting strategies, bridge reliability, fatigue and corrosion, extreme loads, advanced experimental simulations, and advanced computer simulations, among others. This volume provides both an up-to-date overview of the field of bridge engineering and significant contributions to the process of more rational decision-making on bridge maintenance, safety, risk, management and life-cycle performance of bridges for the purpose of enhancing the welfare of society. The Editors hope that these Proceedings will serve as a valuable reference to all concerned with bridge structure and infrastructure systems, including students, researchers and engineers from all areas of bridge engineering.

Experimental and Numerical Investigations on Bond Durability of CFRP Strengthened Concrete Members Subjected to Environmental Exposure

Developments in fiber-reinforced polymer (FRP) composites for civil engineering

Debonding Failure of Carbon Fiber Reinforced Polymer Reinforced Concrete Beams and In-situ Monitoring Schemes

Evaluation of Long Term Durability in Concrete with External Pre-saturated CFRP Laminate

Environmental Durability of Reinforced Concrete Deck Girders Strengthened with Surface-bonded Carbon Fiber-reinforced Polymer

Durability of Carbon Fibre Reinforced Polymer Concrete Bond Under Sustained Load in Harsh Environment

- Introduction - Design specification - Design process overview - Design of composite - Structural design - Implementation - Tests - Verification - Monitoring - References Reviews Fibre reinforced polymer (FRP) composites have been used for many years in the aircraft and shipbuilding industries. They are now being used in a variety of construction applications where their light weight, high strength, stiffness, durability, and ease of installation makes them cost effective. This is particularly true in the repair and rehabilitation of existing infrastructure. This book provides design guidance on the use of fibre reinforced polymer composites, based on the results of two major programmes funded by the DETR. The book demonstrates that fibre reinforced polymer composites can be used with complete confidence in structural applications. Likewise, guidance is given on short-term and long-term behaviour and how this can be interpreted within a factual design situation. Also included are case studies of projects on the London Underground network, alongside contributions from industry research groups. FRP composites can offer a performance or cost benefit over traditional solutions. As there are no official standards for this type of work, this first attempt at producing design recommendations will be a vital resource for structural engineers. Quality Concrete, October 2001

Strengthening reinforced concrete (RC) members using fiber reinforced polymer (FRP) composites through external bonding has emerged as a viable technique to retrofit/repair deteriorated infrastructure. The interface between the FRP and concrete plays a critical role in this technique. This chapter discusses the analytical and experimental methods used to examine the integrity and long-term durability of this interface. Interface stress models, including the commonly adopted two-parameter elastic foundation model and a novel three-parameter elastic foundation model (3PEF) are first presented, which can be used as general tools to analyze and evaluate the design of the FRP strengthening system. Then two interface fracture models – linear elastic fracture mechanics and cohesive zone model – are established to analyze the potential and full debonding process of the FRP–concrete interface. Under the synergistic effects of the service loads and environments species, the FRP–concrete interface experiences deterioration, which may reduce its long-term durability. A novel experimental method, environment-assisted subcritical debonding testing, is then introduced to evaluate this deteriorating process. The existing small cracks along the FRP–concrete interface can grow slowly even if the mechanical load is lower than the critical value. This slow-crack growth process is known as environment-assisted subcritical cracking. A series of subcritical cracking tests are conducted using a wedge-driven test setup t o gain the ability to accurately predict the long-term durability of the FRP–concrete interface.

This book presents selected papers presented during Fatigue Durability India 2019. The contents of this volume discuss advances in the field of fatigue, durability, and fracture, and cover mechanical failure and its applications. The chapters cover a wide spectrum of topics, including design, engineering, testing and computational evaluation of the components or systems for fatigue, durability, and fracture mechanics. The contents of this book will appeal not only to academic researchers, but also to design engineers, failure analysts, maintenance engineers, certification personnel, and R&D professionals involved in a wide variety of industries.

Carbon Fiber Reinforcement Polymer (CFRP) materials are widely used to strengthen reinforced concrete structures because they are light weight, have high strength, and are relatively easy to install. In strengthening applications, CFRP strips are typically attached to the concrete surface using epoxy resin with fibers oriented in the direction needing additional tensile strength. However, if CFRP strips rely exclusively on bond strength with concrete, only 40% to 50% of the CFRP tensile strength can be developed before debonding occurs. In order to fully develop the tensile strength of CFRP strips, some form of anchorage is needed. CFRP anchors can be applied with relative ease and have recently been shown to provide effective anchorage of CFRP strips to concrete members. In many cases, however, current anchorage details may resulting in fracture or failure of CFRP anchors prior to developing the full strength of CFRP strips. Many design parameters, the effects of which are not well understood, can affect the behavior and strength of CFRP anchors. Moreover, previous studies have demonstrated that the quality of installation can influence anchor strength substantially. The objectives of the study presented are to: 1) provide engineers with design guidelines for CFRP anchors, and 2) deliver a reliable test for controlling the quality of installation and materials of CFRP anchorage systems. In all, 39 tests on 6"×6"×24" rectangular concrete beams were conducted to study the influence of five parameters on CFRP anchor strength and effectiveness: 1) the width of the CFRP strip being developed, 2) the

material ratio of CFRP anchor to CFRP strip, 3) the concrete strength, 4) the length/angle of anchor fan, and 5) the bond between CFRP strip and concrete (bonded/unbonded). The same tests also served to develop the test methodology for quality control of the CFRP anchorage system. Based on experimental results, guidelines for designing CFRP anchors are proposed. A test specimen and methodology are also proposed for qualifying CFRP materials and anchorage-system installations. A Finite Element (FE) formulation was selected to provide a computational tool that is suited for simulating the behavior of CFRP strips and CFRP anchors. The ability of the selected FE formulation to reproduce the effects on behavior of varying the anchor-material ratio, concrete strength, length of anchor fan, and bond conditions was investigated. Six FE simulations were built by adjusting simulation parameters and comparing results with six experimental tests. Comparisons between experimental and numerical results indicate that the proposed FE formulation and parameter selections reproduced load-deflection and local strain behaviors with high fidelity.

Bridge Safety, Maintenance, Management, Life-Cycle, Resilience and Sustainability

Durability of Reinforced Concrete Members Strengthened with CFRP Plates and Subjected to Moisture and Salts

6. Assessing the durability of the interface between fiber-reinforced polymer (FRP) composites and concrete in the rehabilitation of reinforced concrete structures

FRP Composites

Durability of Concrete Members Strengthened with CFRP Sheets Under Harsh Environmental Conditions

Advances in Engineering Structures, Mechanics & Construction

The deterioration of concrete structures is a major concern to the infrastructure community. Typical sources of deterioration may include aging, increased service load, and environmental damage. Structural rehabilitation using carbon fiber reinforced polymer (CFRP) sheets has recently attracted attention to the infrastructure community because of the superior strengthening effects in comparison to conventional repair methods. The CFRP sheets may be bonded on the deteriorated concrete structure using bonding agents to enhance load-carrying capacity. The most important consideration in such a strengthening method may be the long term durability under harsh environmental conditions. Furthermore, premature debonding of bonded CFRP sheets may also cause significant losses of the strengthening effects. Although extensive research has been reported on the debonding mechanism of CFRP sheets, there is still lack of understanding on the durability of CFRPs subject to low temperature effects. This book mainly focused on the durability performance of concrete members strengthened with CFRP sheets subjected to harsh environments.

Carbon Fibre Reinforced Polymer (CFRP) has great potential in civil engineering applications. It is used extensively in extending the structural capacity or service life of aging structures. CFRP is one of the best alternatives to traditional retrofitting materials. It has a very high strength-to-weight ratio with good resistance to environmental effects. Together with the fibres, the adhesive and the substratum are the main constituents of the CFRP bonding systems. However, with high quality plated CFRP, the latter two components introduce some doubts about the system's performance. There is therefore a crucial research need to investigate the effects of environmental exposures on the system under loading conditions. In the present work, the effects of extreme environmental exposures on the bond properties between externally-applied carbon fibre reinforced polymer (CFRP) and concrete were investigated. Preloaded CFRP-concrete samples at various load intensities were exposed to several conditions. The exposure conditions were temperature cycles with humidity, constant temperature at increasing humidity, soaking in saline water at different temperatures, and different salt concentrations. Finally, actual extreme marine site environments including direct exposure to sunlight were explored. The change of bond characteristics between the externally-applied CFRP and concrete due to permanent loads, aging, and exposure conditions were used as measures of degradation effects. Other properties such as the development of the strain field with load, bond-slip relationships, detection of cracking intensity and location were evaluated using photogrammetry and acoustic emission techniques. Tensile pull-out and torsional shear strength were also explored. A Neural Network method was implemented for the prediction of bond strength and the expected failure of preloaded samples in different environments. The objective of the study was to understand the behaviour of preloaded concrete-CFRP bonding systems and evaluate the changes in the bond properties due to combinations of factors in harsh environments. It was found that high temperature and the combined aggressive site conditions were the major factors leading to sample failure.

Volume is indexed by Thomson Reuters CPCI-S (WoS). Following the great progress made in Computational Mechanics and Materials, the 2011 International Workshop on Computational Mechanics, Materials and Engineering Applications (CMMEA 2011) aimed at providing a forum for the presentation and discussion of state-of-the-art developments in Computational Mechanics and Engineering Applications, Building Materials, Geotechnical & Soil Engineering and Materials Science and Engineering Applications. The emphasis was placed on basic methodologies, scientific developments and engineering applications.

About 77,600 bridges throughout the United States in the Federal Highway Association (FHWA) bridge database are listed as structurally

deficient. This has created a need to either replace or strengthen bridges quickly and efficiently. Due to high costs for total replacement of deficient bridges, strengthening of existing bridges is a more economical alternative. A technique that has been developing over the past two decades is the strengthening of bridges using carbon fiber reinforced polymer (CFRP) sheets. The CFRP sheets are attached to the bottom of the bridge girders using structural adhesives so that the CFRP becomes an integral part of the bridge and carries a portion of the flexural loading. The CFRP sheets allow for an increase in the capacity of the bridge with minimal increase in the weight of the structure due to CFRP having a low density. Because the CFRP is expected to be an integral component and carry some of the long-term loading it is important to understand the long-term durability of the composite section. This thesis is part of a larger project, in which the long-term durability of the CFRP composite on concrete beams is investigated experimentally. The CFRP strengthened beams are exposed to fatigue testing and thermal-humidity cycling followed by failure testing. The testing scheme for this experiment allows for the investigation of the individual effects of fatigue and thermal-humidity loading as well as to explore the effects from combined fatigue and thermal-humidity loading. The investigation of the combined effects is a unique aspect of this experiment that has not been performed in prior studies. Results indicate that a polyurethane-based adhesive could provide a more durable bond for the CFRP-concrete interface than possible with epoxy-based adhesives.

Selected, Peer Reviewed Papers from the Eight International Conference on Composite Science and Technology (ICCST8) 2011, Kuala Lumpur, Malaysia, March 22-24, 2011

Fatigue, Durability, and Fracture Mechanics

Proceedings of an International Conference on Advances in Engineering Structures, Mechanics & Construction, held in Waterloo, Ontario, Canada, May 14-17, 2006

2nd International Conference on Concrete Repair, Rehabilitation and Retrofitting, ICCRRR-2, 24-26 November 2008, Cape Town, South Africa

Issues in Structural and Materials Engineering: 2013 Edition

Environmental Durability of Reinforced Concrete Deck Girders Strengthened for Shear with Surface-bonded Carbon Fiber-reinforced Polymer

Inhaltsangabe:Zusammenfassung: Im Dezember 2002 wurde die erste österreichische Richtlinie bezüglich Stahlbetonverstärkungen mit aufgeklebten CFK-Lamellen veröffentlicht. Das vorrangige Ziel der vorliegenden Diplomarbeit ist, die Durchführbarkeit der neuen Richtlinie - mit speziellem Augenmerk auf Qualitätssicherung - anhand Europas größter CFK-Baustelle (die Wiener Marxerbrücke) zu überprüfen. Die Diplomarbeit enthält eine Übersicht über Eigenschaften und Anforderungen an CFK, deren gängigste Anwendungen als Verstärkung und eine Beschreibung des Hauptbezugsobjekts Marxerbrücke. Die Methoden der Qualitätssicherung nach der neuen Richtlinie werden erklärt und Resultate aus der Qualitätssicherung auf der Marxerbrücke inklusive einer Analyse von Fehlstellen und Sanierungsmethoden werden präsentiert. Anschließend werden die Resultate aus der Qualitätssicherung auf der Marxerbrücke mit denen von vier anderen CFK-verstärkten Bezugsobjekten verglichen. Abschließend werden Veränderungen bezüglich der Methoden der Qualitätssicherung vorgeschlagen und Empfehlungen für eine zukünftige Ausgabe der österreichischen Richtlinie werden geäußert. Inhaltsverzeichnis:Table of Contents: AbstractI Deutsche KurzfassungII AcknowledgementsIII Table of contents4 1.Content and aims of the thesis7 2.Strengthening with fibre reinforced polymers8 Fibre Reinforced Polymers9 Types of fibres9 2.1.1CFRP products and their properties10 Comparison of strengthening with carbon fibre reinforced polymers and externally bonded steel12 Differences in behaviour under tension12 Advantages of carbon fibre reinforced polymers12 2.1.2Disadvantages of carbon fibre reinforced polymers14 Guidelines and reference works in Austria concerning CFRP and design of strengthening elements14 2.1.3Verifications of the strengthening system according to the Austrian guidelines15 2.1.4Design bending moment capacity17 Preliminary measures and application of CFRP19 Examination of the state of the concrete member before surface preparation19 2.1.5Surface preparation and repair of the concrete member20 2.1.6Application of CFRP Reinforcement21 Basic techniques of strengthening with CFRP21 2.1.7Selected special techniques of strengthening with CFRP24 3.main reference object: Marxerbridge26 General description of the widening of the Marxerbridge26 Geographical position26 Arrangement of the structure of the Marxerbridge27 Division and numeration of the structure27 3.1.1Technical data [...]

The range of fibre-reinforced polymer (FRP) applications in new construction, and in the retrofitting of existing civil engineering infrastructure, is continuing to grow worldwide. Furthermore, this progress is being matched by advancing research into all aspects of

analysis and design. The Second International Conference on FRP Composites in
This book presents the proceedings of an International Conference on Advances in Engineering Structures, Mechanics & Construction, held in Waterloo, Ontario, Canada, May 14-17, 2006. The contents include contains the texts of all three plenary presentations and all seventy-three technical papers by more than 153 authors, presenting the latest advances in engineering structures, mechanics and construction research and practice.
Bridge Maintenance, Safety, Management, Life-Cycle Sustainability and Innovations contains lectures and papers presented at the Tenth International Conference on Bridge Maintenance, Safety and Management (IABMAS 2020), held in Sapporo, Hokkaido, Japan, April 11–15, 2021. This volume consists of a book of extended abstracts and a USB card containing the full papers of 571 contributions presented at IABMAS 2020, including the T.Y. Lin Lecture, 9 Keynote Lectures, and 561 technical papers from 40 countries. The contributions presented at IABMAS 2020 deal with the state of the art as well as emerging concepts and innovative applications related to the main aspects of maintenance, safety, management, life-cycle sustainability and technological innovations of bridges. Major topics include: advanced bridge design, construction and maintenance approaches, safety, reliability and risk evaluation, life-cycle management, life-cycle sustainability, standardization, analytical models, bridge management systems, service life prediction, maintenance and management strategies, structural health monitoring, non-destructive testing and field testing, safety, resilience, robustness and redundancy, durability enhancement, repair and rehabilitation, fatigue and corrosion, extreme loads, and application of information and computer technology and artificial intelligence for bridges, among others. This volume provides both an up-to-date overview of the field of bridge engineering and significant contributions to the process of making more rational decisions on maintenance, safety, management, life-cycle sustainability and technological innovations of bridges for the purpose of enhancing the welfare of society. The Editors hope that these Proceedings will serve as a valuable reference to all concerned with bridge structure and infrastructure systems, including engineers, researchers, academics and students from all areas of bridge engineering.
Advances in Structural Mechanics and Applications
Maintenance, Safety, Risk, Management and Life-Cycle Performance of Bridges
Durability of Fiber Reinforced Polymer (FRP) Composites for Construction
Proceedings of the Tenth International Conference on Bridge Maintenance, Safety and Management (IABMAS 2020), June 28-July 2, 2020, Sapporo, Japan
Non-Metallic (FRP) Reinforcement for Concrete Structures
Environmental Durability Evaluation of Externally Bonded Composites

ABSTRACT: The load capacity of PR corroded beams strengthened with CFRP was about 30% higher than for control beams, and the stiffness was restored to the original value. Based on the results and observations, a corrosion damage rating system for reinforced concrete beams was developed.

Dealing with a wide range of non-metallic materials, this book opens up possibilities of lighter, more durable structures. With contributions from leading international researchers and design engineers, it provides a complete overview of current knowledge on the subject.

The Second International Conference on Concrete Repair, Rehabilitation and Retrofitting (ICCRRR 2005) was held in Cape Town, South Africa, from 24-26 November 2008. The Conference followed the very successful First International Conference, also in Cape Town in 2005, and continued as a collaborative venture by researchers from the South African Research Programme in Concrete Materials (based at the Universities of Cape Town and The Witwatersrand) and The Construction Materials Sections at Leipzig University and MFPA Leipzig in Germany. The background, in industry and the state of national infrastructures, continues to be highly challenging and demanding. The facts remain that much of our concrete infrastructure deteriorates at unacceptable rates, that we need appropriate tools and techniques to undertake the vast task of sound repair, maintenance and rehabilitation of such infrastructure, and that all this must be undertaken with due cognisance of the limited budgets available for such work. New ways need to be found to extend the useful life of concrete structures cost-effectively. Confidence in concrete as a viable construction material into the 21st century needs to be retained and sustained, particularly considering the environmental challenges that the industry and society now face. The conference proceedings contain papers, presented at the conference, and classified into a total of 12 sub themes which can be grouped under the three main themes of (i) Concrete durability aspects, (ii) Condition assessment of concrete structures, and (iii) Concrete repair, rehabilitation and retrofitting. The major interests in terms of submissions exists in the fields of innovative materials for durable concrete construction, integrated service life modelling of reinforced concrete structures, NDE/NDT and measurement techniques, repair methods and materials, and structural strengthening and retrofitting techniques. The large number of high-quality papers presented and the wide range of relevant topics covered confirm that these proceedings will be a valued reference for many working in the important fields of concrete durability and repair, and that they will form a suitable base for discussion and provide suggestions for future development and research. Set of book of abstracts (476 pp) and a searchable full paper CD-ROM (1396 pp).

Long-term durability of surface-bonded carbon fiber-reinforced polymer (CFRP) U-wraps for shear strengthening of reinforced concrete (RC) bridge members remains uncertain due to the limited field experience with these materials. This paper provides experimental results from the testing of full-scale RC bridge girder specimens after exposure to prolonged freeze-thaw cycling. CFRP shear contributions seen in experimental results were estimated using a refined base capacity prediction (Response-2000) and compared to predicted CFRP shear contributions (ACI-440). A decrease in CFRP shear contribution was seen due to freeze-thaw exposure when moisture was present at the CFRP-concrete bond interface.

Concrete Repair, Rehabilitation and Retrofitting II

Advanced Polymer Composites for Structural Applications in Construction

Life Extension and Strengthening of Metallic Structures

FRP Composites in Civil Engineering - CICE 2004

Durability and Inspection of Concrete Strengthened with Carbon Fiber Reinforced Polymer Composites

Bridge Maintenance, Safety, Management, Life-Cycle Sustainability and Innovations

The use of fiber reinforced plastic (FRP) composites for prestressed and non-prestressed concrete reinforcement has developed into a technology with serious and substantial claims for the advancement of construction materials and methods. Research and development is now occurring worldwide. The 20 papers in this volume make a further contribution in advancing knowledge and acceptance of FRP composites for concrete reinforcement. The articles are divided into three parts. Part I introduces FRP reinforcement for concrete structures and describes general material properties and manufacturing methods. Part II covers a three-continent perspective of current R&D, design and code implementations, and technical organizations' activities. Part III presents an in-depth description of commercially-available products, construction methods, and applications. The work is intended for engineers, researchers, and developers with the objective of presenting them with a world-wide cross-section of initiatives, representative products and significant applications.

The durability of three types of fiber reinforced polymers (CFRP plate, CFRP fabric, and GFRP fabric) used for strengthening concrete structures was evaluated. Both material and bond specimens were subjected to conditioning treatments that are likely to occur in civil infrastructure. Samples were exposed to 100% humidity, alkalinity, salt water, dry heat, freeze/thaw cycling, vehicle fuel, and UV radiation for various durations and then were tested and compared to baseline sample values to determine if deterioration took place at a material or bond level. The CFRP plate tensile specimens experienced an increase in strength from the benefits of a post-curing period while at the same time experienced a decrease in thickness. The decrease in thickness was most likely due to chemical degradation of the resin matrix, and/or as a result of post-curing. The CFRP fabric experienced a post-curing period for a much shorter duration than the plate. The bond specimens exposed to elevated temperatures, moisture, and chemical solutions suffered an apparent trend of deterioration along the bond line, which progressed into material failure for specimens exposed for longer durations. The GFRP fabric bond specimens followed a trend similar to the CFRP fabric specimens when exposed to moisture and chemical solutions. The rate of deterioration due to the chemical attack of alkalinity was much faster than the attack due to salt water. Reinforced concrete beams strengthened with the three materials were exposed to a combined treatment of freeze/thaw cycling and UV radiation and then tested in flexure and compared to the performance of non-conditioned strengthened beams. The GFRP fabric specimens were the only beams impacted by the conditioning. The treatment resulted in fiber surface pitting and, based on the observed failure modes, increased brittleness of the material.

10th International Conference on FRP Composites in Civil Engineering

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Composite Science and Technology

Fiber-Reinforced-Plastic (FRP) Reinforcement for Concrete Structures

Computational Mechanics, Materials and Engineering Applications

Design Guidelines for Durability of Bonded CFRP Repair/strengthening of Concrete Beams