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Advanced Composites
Of The Sixth International Symposium On FRP Reinforcement For Concrete Structures (FRPRCS-6)
Fiber-reinforced Polymer (FRP) Reinforcement for Concrete Structures
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Advanced Composites
Composite construction is prevalent in advanced structural systems where components of different materials are combined in the same structure to improve the performance of strong and economic structural sections. Maintaining continuity between the different structural components to produce monolithic structural behavior is challenging because of differences in the mechanical properties of these materials in terms of stiffness, strength, and ductility. The different components of the composite section are typically joined using adhesives and/or mechanical anchors to produce partial or full composite action. This dissertation discusses two types of shear interfaces intended to result in structural composite behavior. The first type of interface that is part of this dissertation focuses on bonded and mechanically anchored externally applied FRP sheets used in concrete structure for rehabilitation of concrete structures. The second type of connection is a new wood-concrete composite that includes a perforated steel connector bonded to engineered wood elements to transfer shear stresses to cast-in-place concrete. Fiber reinforced polymer (FRP) materials have been confirmed as an excellent option for strengthening existing or even newly constructed concrete structures. However, FRP sheets may debond before reaching a high level of FRP stress. This behavior adversely affects the efficiency of using FRP materials for strengthening concrete structures. FRP-anchors have been added to the bonded joints to delay or avoid debonding and allow FRP sheets to reach their ultimate strength. Yet, the behavior of carbon fiber anchors is not well understood, particularly the effect of the dimensional and geometric properties of the anchors on the total strength of FRP-concrete joints. Therefore, the influence of key anchor parameters on joint behavior were examined in this research through analytical simulations. The parameters investigated were: the number of anchors used in the joint, the distance between anchors, anchor shaft depth, anchor shaft diameter, anchor splay angle, and anchor splay diameter. A general-purpose finite element software (ABAQUS) was used to study the behavior of the anchored FRP-concrete joints having different anchor configurations and geometries. Different three-dimensional finite element models were used to describe the different components of the FRP-concrete joint. These different components were categorized based on the different materials, geometric shapes and functional roles of each part or component. Consequently, five different components were considered in the finite element models to represent the FRP-concrete joint. These components are the concrete substrate, the FRP sheet, the adhesive layer, the FRP anchor, and the adhesive envelopes around the anchors (for modeling the interface between concrete, FRP sheet, and the FRP anchors). Based on this study, design recommendations for fiber reinforced polymer anchors were developed to determine the number of anchors, distance between anchors, anchor shaft depth, anchor shaft diameter, anchor splay angle, and anchor splay diameter required to achieve a goal strength. The finite element analysis can be extended to model full-scale structural members strengthened with fiber-reinforced material under different loading conditions building on the findings from this research. The second type of composite application included in this dissertation focuses on new structural deck systems that benefit from the use of wood as a lightweight, sustainable substructure and concrete as a wear-resistant, vibration damping top element. These systems employ metallic connectors to transfer shear stresses between the wood and the concrete leading to full or partial composite action for strength and stiffness benefits. Results of finite element analysis and a parametric investigation are presented for one type of connector similar to those available commercially: a perforated steel plate of which half is epoxied into a groove in the wood member while the other half is embedded in a concrete slab. The analysis was first validated against experimental push-out tests performed on a commercial product and then employed to examine the effect of several parameters of the connection: thickness of plate; insulation gap between concrete and wood; depth of embedment in concrete; and depth of embedment in wood. The results showed that thickness predictably affects shear capacity as well as ductility and stiffness (slip moduli) of the connector. This dissertation highlights the importance of including parameters that affect the response of joints between dissimilar materials in order to properly capture their behavior through numerical models. The detailed parametric studies presented in this research can form the basis for development of design recommendations for these types of connections. Given the expense associated with laboratory experimentation, the tools used in this research provide an inexpensive complement to physical testing in the development of robust and reliable equations that can be incorporated into design standards. Mechanics of Structures and Materials: Advancements and Challenges is a collection of peer-reviewed papers presented at the 24th Australasian Conference on the Mechanics of Structures and Materials (ACMSM24, Curtin University, Perth, Western Australia, 6-9 December 2016). The contributions from academics, researchers and practitioners...
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engineers from Australasian, Asia-pacific region and around the world, cover a wide range of topics, including: • Structural mechanics • Computational mechanics • Reinforced and prestressed concrete structures • Steel structures • Composite structures • Civil engineering materials • Fire engineering • Coastal and offshore structures • Dynamic analysis of structures • Structural health monitoring and damage identification • Structural reliability analysis and design • Structural optimization • Fracture and damage mechanics • Soil mechanics and foundation engineering • Pavement materials and technology • Shock and impact loading • Earthquake loading • Traffic and other man-made loads • Wave and wind loading • Thermal effects • Design codes

Mechanics of Structures and Materials: Advancements and Challenges will be of interest to academics and professionals involved in Structural Engineering and Materials Science. This volume highlights the latest advances, innovations, and applications in the field of fibre reinforced concrete (FRC) and discusses a diverse range of topics concerning FRC: rheology and early-age properties, mechanical properties, codes and standards, long-term properties, durability, analytical and numerical models, quality control, structural and industrial applications, smart FRC’s, nanotechnologies related to FRC, textile reinforced concrete, structural design and UHPFRC. The contributions present improved traditional and new ideas that will open novel research directions and foster multidisciplinary collaboration between different specialists. Although the symposium was postponed, the book gathers peer-reviewed papers selected in 2020 for the RILEM-fib International Symposium on Fibre Reinforced Concrete (BEFIB). This book is a collection of select papers presented at the Tenth Structural Engineering Convention 2016 (SEC-2016). It comprises plenary, invited, and contributory papers covering numerous applications from a wide spectrum of areas related to structural engineering. It presents contributions by academics, researchers, and practicing structural engineers addressing analysis and design of concrete and steel structures, computational structural mechanics, new building materials for sustainable construction, mitigation of structures against natural hazards, structural health monitoring, wind and earthquake engineering, vibration control and smart structures, condition assessment and performance evaluation, repair, rehabilitation and retrofit of structures. Also covering advances in construction techniques/practices, behavior of structures under blast/impact loading, fatigue and fracture, composite materials and structures, and structures for non-conventional energy (wind and solar), it will serve as a valuable resource for researchers, students and practicing engineers alike.

IMDC-SDSP conference offers an exceptional platform and opportunity for practitioners, industry experts, technocrats, academics, information scientists, innovators, postgraduate students, and research scholars to share their experiences for the advancement of knowledge and obtain critical feedback on their work. The timing of this conference coincides with the rise of Big Data, Artificial Intelligence powered applications, Cognitive Communications, Green Energy, Adaptive Control and Mobile Robotics towards maintaining the Sustainable Development and Smart Planning and management of the future technologies. It is aimed at the knowledge generated from the integration of the different data sources related to a number of active real-time applications in supporting the smart planning and enhance and sustain a healthy environment. The conference also covers the rise of the digital health, well-being, home care, and patient-centred era for the benefit of patients and healthcare providers; in addition to how supporting the development of a platform of smart Dynamic Health Systems and self-management. Fibre-reinforced polymer (FRP) reinforcement has been used in construction as either internal or external reinforcement for concrete structures in the past decade. This book provides the latest research findings related to the development, design and application of FRP reinforcement in new construction and rehabilitation works. The topics include FRP properties and bond behaviour, externally bonded reinforcement for flexure, shear and confinement, FRP structural shapes, durability, member behaviour under sustained loads, fatigue loads and blast loads, prestressed FRP tendons, structural strengthening applications, case studies, and codes and standards. "Advances in FRP Composites in Civil Engineering" contains the papers presented at the 5th International Conference on Fiber Reinforced Polymer (FRP) Composites in Civil Engineering in 2010, which is an official conference of the International Institute for FRP in Construction (IFC). The book includes 7 keynote papers which are presented by top professors and engineers in the world and 203 papers covering a wide spectrum of topics. These important papers not only demonstrate the recent advances in the application of FRP composites in civil engineering, but also point to future research endeavors in this exciting area. Researchers and professionals in the field of civil engineering will find this book is exceedingly valuable. Prof. Lieping Ye and Dr. Peng Feng both work at the Department of Civil Engineering, Tsinghua University, China. Qingrui Yue is a Professor at China Metallurgical Group Corporation. ABAQUS software is a general-purpose finite element simulation package mainly used for numerically solving a wide variety of design engineering problems; however, its application to simulate the dynamic structures within the civil engineering domain is highly complicated. Therefore, this book aims to present specific complicated and puzzling challenges encountered in the application of Finite Element Method (FEM) for solving the problems related to Structural Dynamics using ABAQUS software that can fully utilize this method in complex simulation and analysis. Various chapters of this book demonstrate the process for the modeling and analysis of impenetrable problems through simplified step-by-step illustration by presenting screenshots from ABAQUS software in each part/step and showing various graphs. Highlights: Focuses on solving problems related to Structural Dynamics using ABAQUS software Helps to model and analyze the different types of structures under various dynamic and cyclic loads Discusses the simulation of irregularly-shaped objects comprising several different materials with multipart boundary conditions Includes the application of various load effects to develop structural models using ABAQUS software Covers a broad array of applications such as bridges, offshore, dams, and seismic resistant systems Overall, this book is aimed at graduate students, researchers, and professionals in structural engineering, solid mechanics, and civil engineering. This edited volume on challenges in structural and bridge engineering brings together contributions to this important area of engineering research. The volume presents findings and case studies on fundamental and applied aspects of structural engineering, applied to buildings, bridges and infrastructures in general, and heritage patrimony. The scope of the volume focuses on the application of advanced experimental and numerical techniques and new technologies to the built environment. The volume is based on the best contributions to the 2nd GeoMEast International Congress and Exhibition on Sustainable Civil Infrastructures, Egypt 2018 – The official international congress of the Soil-Structure Interaction Group in Egypt (SSIGE). This book provides a collection of recent research works, related to structural stability and durability, service life, reinforced concrete structures, recycled materials, and sustainability with endogenic materials. Intended as an overview of the current state of knowledge, the book will benefit scientists, students, practitioners, lecturers and other interested parties. At the same time, the topics covered are relevant to a variety of scientific and engineering disciplines, including civil, materials and mechanical engineering. Bridge Maintenance, Safety, Management, Resilience and Sustainability contains the lectures and papers presented at The Sixth International Conference on Bridge Maintenance, Safety and Management (IABMAS 2012), held in Stresa.
Lake Maggiore, Italy, 8-12 July, 2012. This volume consists of a book of extended abstracts (800 pp) and a DVD (4057 pp). This book highlights current research and developments in the area of Structural Engineering and Construction Management, which are important disciplines in Civil Engineering. It covers the following topics and categories of Structural Engineering. The main chapters/sections of the proceedings are Structural and Solid Mechanics, Construction Materials, Systems and Management, Loading Effects, Construction Safety, Architecture & Architectural Engineering, Coastal Engineering, Foundation engineering, Materials, Sustainability. The content of this book provides necessary knowledge for construction management practices, new tools and technologies on local and global levels in civil engineering which can mitigate the negative effects of built environment.Concrete Solutions contains the contributions from some 30 countries to Concrete Solutions, the 6th International Conference on Concrete Repair (Thessaloniki, Greece, 20-23 June 2016). Strengthening and retrofitting are major themes in this volume, with NDT and electrochemical repair following closely, discussing the latest advances and technologies in concrete repair. The book brings together some interesting and challenging theoretical approaches and questions if we really understand and approach such topics as corrosion monitoring correctly. Concrete Solutions is an essential reference work for those working in the concrete repair field, from engineers to architects and from students to clients. 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. Subsequent conferences have seen the Series partnering with the University of Padua (Italy) in 2009, with TU Dresden (Germany) in 2011 and with Queen’s University Belfast (Northern Ireland) in 2014. In 2016 Thessaloniki (Greece) hosted the conference, partnering with both Aristotle University of Thessaloniki (AUTH) and Democritus University of Thrace (DUTH). The next conference in the series will be held in 2019 in Istanbul. The modelling of glass fibre reinforced polymer (GFRP) reinforced, concrete beams was conducted by the finite element analysis software ABAQUS. The study extended upon the work done by Joseph Stoner (2015) to calibrate the Concrete Damaged Plasticity (CDP) model, with the intent to ultimately complement laboratory testing in a research setting. Furthermore, current strength prediction methods for beams reinforced with fibre reinforced polymer (FRP) were evaluated against a database of tested beams collected from literature. The validity of the proposed ABAQUS models was assessed against selected beams from the database. Finally, a parametric study was conducted on 12 GFRP reinforced beams, over 12 slenderness ratios, to study the effects of slenderness. The database of tested beams consisted of beams that failed in shear, as tests on slender beams reinforced with FRP are scarce. The strength prediction models were therefore evaluated on their ability to predict shear capacity. The models included in the analysis are the CSA S806-12, the ACI440.1R-15, the Japan Society of Civil Engineers (JSCE), and the Intelligent Sensing for Innovative Structures (ISIS) Canada Manual No. 3 shear models, as well as a prediction model proposed by Nehdi et al. (2007). The study concluded that Nehdi model most accurately predicts the shear capacity for beams with transverse reinforcement, with the remainder of the models providing very conservative values. For beams without shear reinforcement, all models provided good estimates for the shear capacity, with the CSA S806-12 model matching most closely to experimental data. The ABAQUS models proposed by Stoner were evaluated against a series of 8 beams taken from literature: two beams without shear reinforcement, and six with shear reinforcement. The results validated the recommendations made by Stoner, and verified the use of 30° dilation concrete to model beams without stirrups, and 50° dilation concrete to model beams with stirrups. Further research was deemed necessary to accurately model beams that exhibited both flexural crushing and stirrup rupture. The results of the parametric study suggested that the beams without shear reinforcement required large shear span to depth ratios to fail in flexure, exceeding ratios of 15. The beams with shear reinforcement failed in flexure at slenderness ratios approaching 10, demonstrating the increased shear strength provided by the stirrups. The increase in slenderness ratio required to fail in flexure (compared to steel reinforced beams) is attributed to the larger tensile strength of GFRP bars. Furthermore, an investigation into the shear capacity prediction methods of CSA S806-12 yielded that the model under-predicts the stirrup contribution to shear capacity. Further investigation determined the most likely cause was the modelling of the confinement induced by the stirrups. This book gathers the proceedings of the 1st Global Civil Engineering Conference, GCEC 2017, held in Kuala Lumpur, Malaysia, on July 25–28, 2017. It highlights how state-of-the-art techniques and tools in various disciplines of Civil Engineering are being applied to solve real-world problems. The book presents interdisciplinary research, experimental and/or theoretical studies yielding new insights that will advance civil engineering methods. The scope of the book spans the following areas: Structural, Water Resources, Geotechnical, Construction, Transportation Engineering and Geospatial Engineering applications. Fibre reinforced plastics are increasingly being used as replacements for steel reinforcement in concrete structures. The reinforcement can be untensioned, or it can be in the form of prestressing tendons. It is also suitable for gluing onto the outside of a structure to improve flexural or shear performance. This book provides up-to-date research results to give engineers confidence in their design methods. 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 PadoThe 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. Subsequent conferences have seen us partnering with the University of Padua in 2009 and with TU Dresden in 2011. This conference is being held for the first time in the UK, in association with Queen’s University Belfast and brings together delegates from 36 countries to discuss the latest advances and technologies in concrete repair. Earlier conferences were dominated by electrochemical repair, but there has been an increasing shift to more unusual methods, such as bacterial repair of concrete plus an increased focus on service life design aspects and modelling, with debate and discussion on the best techniques and the validity of existing methods. Repair of heritage structures is also growing in importance and a number of the papers have focused on the importance of getting this right, so that we may preserve our rich cultural heritage of historic structures. This book is an essential reference work for those working in the concrete repair field, from Engineers to Architects and from Students to Clients. Engineering practice has revealed that innovative technologies’ structural applications require new design concepts related to materials with mechanical properties tailored for construction purposes. This would allow the efficient use of engineering materials. The efficiency can be understood in a simplified and heuristic manner as the optimization of performance and the proper combination of structural components, leading to the consumption of the least amount of natural resources. The solution to the eco-optimization problem, based on the adequate characterization of the materials, will enable implementing environmentally friendly engineering principles when the efficient use of advanced materials guarantees the required structural safety. Identifying fundamental relationships between the structure of advanced composites and their physical
properties is the focus of this book. The collected articles explore the development of sustainable composites with valorized manufacturability corresponding to Industrial Revolution 4.0 ideology. The publications, amongst others, reveal that the application of nano-particles improves the mechanical performance of composite materials; heat-resistant aluminum composites ensure the safety of overhead power transmission lines; chemical additives can detect the impact of temperature on concrete structures. This book demonstrates that construction materials' choice has considerable room for improvement from a scientific viewpoint, following heuristic approaches. Fibre-reinforced polymer (FRP) reinforcement has been used in construction as either internal or external reinforcement for concrete structures in the past decade. This book provides the latest research findings related to the development, design and application of FRP reinforcement in new construction and rehabilitation works. The topics include FRP properties and bond behaviour, externally bonded reinforcement for flexure, shear and confinement, FRP structural shapes, durability, member behaviour under sustained loads, fatigue loads and blast loads, prestressed FRP tendons, structural strengthening applications, case studies, and codes and standards. This study details the development and implementation of a finite element model within a commercial finite element code, Abaqus CAE, for the analysis of reinforced concrete (RC) bridge columns containing interlocking spirals subjected to combined loading conditions including axial, shear, bending, and torsional loads, including the post-peak response. The model is a first of its kind attempt at simulating the response of RC columns with continuous spiral transverse reinforcement and subjected to combined loading conditions including torsion. The model is utilized to determine the quasi-static load-deformation response under various proportions of the input loads and displacements. The resulting quasi-static load-deformations, i.e., 'backbone' relationships, are compared to those experimentally obtained for three 1/2-scale prototype RC bridge columns subjected to constant axial loading and slow reversed cyclic lateral loading resulting in combined flexural, shear, and torsional moment. It was determined that such models can simulate the behavior of such columns with a reasonable level of error for unidirectional loading, but accurate torsional response and numerical stability of such models is difficult to obtain due to convergence errors resulting from a combination of inelastic material models and multi-body constraints used to couple the motion of the column's constituent pieces together. Attempts were made to extend the finite element model to similar RC bridge columns repaired and strengthened with externally bonded fiber reinforced polymer (FRP) composite jackets, however such attempts resulted in convergence failure as the model approached inelastic behavior. Abstract, page iii. Fiber-reinforced polymer (FRP) decks have been increasingly used for new construction and rehabilitation projects worldwide. The benefits of using FRP bridge decks, such as durability, lightweight, high strength, reduced maintenance costs, and rapid installation, outweigh their initial in-place material costs when implemented in highway bridge proThe EURO-C conference series (Split 1984, Zell am See 1990, Innsbruck 1994, Badgastein 1998, St Johann im Pongau 2003, Mayrhofen 2006, Schladming 2010, St Anton am Alberg 2014) brings together researchers and practitioners concerned with theoretical, algorithmic and validation aspects associated with computational simulations of concrete and concrete structures. The conference reviews and discusses research advancements and the applicability and robustness of methods and models for reliable analysis of complex concrete, reinforced concrete and pre-stressed concrete structures in engineering practice. Conference topics and invited papers cover both computational mechanics and computational modelling aspects of the analysis and design of concrete and concrete structures: * Constitutive and Multiscale Modelling of Concrete * Advances in Computational Modelling * Time Dependent and Multiphysics Problems * Performance of Concrete Structures The book is of special interest to researchers in computational concrete mechanics, as well as industry experts in complex nonlinear simulations of concrete structures.Nonlinear Finite Element Analysis of Composite and Reinforced Concrete Beams presents advanced methods and techniques for the analysis of composite and FRP reinforced concrete beams. The title introduces detailed numerical modeling methods and the modeling of the structural behavior of composite beams, including critical interfacial bond-slip behavior. It covers a new family of composite beam elements developed by the authors. Other sections cover nonlinear finite element analysis procedures and the numerical modeling techniques used in commercial finite element software that will be of particular interest to engineers and researchers executing numerical simulations. Gives advanced methods and techniques for the analysis of composite and fiber Reinforced Plastic (FRP) and reinforced concrete beams. Presents new composite beam elements developed by the authors. Introduces numerical techniques for the development of effective finite element models using commercial software Discusses the critical issues encountered in structural analysis Maintains a clear focus on advanced numerical modeling This book gathers contributions from the 15th ICOLD Benchmark Workshop on Numerical Analysis of Dams. The workshop provided an opportunity for engineers, researchers and operators to present and exchange their experiences and the latest advances in numerical modelling in the context of the design, performance and monitoring of dams. Covering various aspects of computer analysis tools and safety assessment criteria, and their development over recent decades, the book is a valuable reference resource for those in the engineering community involved in the safety, planning, design, construction, operation and maintenance of dams. Strengthening of Concrete Structures Using Fiber Reinforced Polymers (FRP): Design, Construction and Practical Applications presents a best practice guide on the structural design and strengthening of bridge structures using advanced Fiber Reinforced Polymer (FRP) composites. The book briefly covers the basic concepts of FRP materials and composite mechanics, while focusing on practical design and construction issues, including inspection and quality control, paying special attention to the differences in various design codes (US, Japan, and Europe) and recommendations. At present, several design guides from the US, Japan, and Europe are available. These guidelines are often inconsistent and do not cover all necessary design and inspection issues to the same degree of detail. This book provides a critical review and comparison of these guidelines, and then puts forward best practice recommendations, filling a significant gap in the literature, and serving as an important resource for engineers, architects, academics, and students interested in FRP materials and their structural applications. Written from a practitioner's point-of-view, it is a valuable design book for structural engineers all over the world. Includes a large quantity of design examples and structural software to facilitate learning and help readers perform routine design Provides recommendations for best practices in design and construction for the strengthening of bridge structures using advanced fiber-reinforced polymer (FRP) composites Presents comprehensive guidelines on design, inspection, and quality control, including laboratory and field testing information This book introduces different advanced composite materials used in construction of civil engineering infrastructures. It reflects the latest manufacturing processes and applications in the civil structures. This book also includes test cases and its validation with finite element method using computer software. Moreover, the book also deals with design methodology of advanced composite materials based on different applications. The comprehensive overview of the state-of-the-art research on the composite materials presented herein is of interest to scientists,