

Strengthening Design Of Reinforced Concrete With Frp Composite Materials

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Non-Metallic (FRP) Reinforcement for Concrete Structures - L. Taerwe 1995-08-03

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.

Categorization and Experimental Evaluation of Anchorage Systems for Fiber-reinforced Polymer Laminates Bonded to Reinforced Concrete Structures - Stephen Vincent Grelle 2011

"While externally-bonded fiber-reinforced polymer (FRP) composites are commonly used for the strengthening of structurally deficient reinforced concrete (RC) members, the topic of anchoring FRP to concrete to achieve higher design strengths has not been addressed. Many innovative systems have been developed to anchor FRP to concrete, but the research involving these anchorage systems is not centralized and is therefore difficult to access. Additionally, systematic testing procedures for evaluating the strength of an anchorage system have not been widely used. To aid in the organization of anchorage system research and facilitate a better understanding of anchorage system behavior, a categorization system was developed based on the understood behavior of the FRP anchorage systems, as well as their potential applications. This new categorization system was used to discuss the applicability of anchorage testing procedures to various types of anchorage. Experimental research involving anchorage systems used for the emergency repair of severely damaged bridge columns was also performed. The anchorage systems included a novel anchorage system that was the focus of the experimental portion of this research. Results from the experimental program show that while the novel anchorage has promise for use in FRP strengthening applications, the assumed behavior of the novel anchorage was inconsistent with the observed behavior. Because detailed design procedures could not be developed using the experimental data, future testing of this anchorage system should be performed in the absence of the large number of variables that affected the anchorage's performance during the column tests"--Abstract, leaf iii.

Strengthening of Reinforced Concrete Structures - L C Hollaway 1999-03-05

The in situ rehabilitation or upgrading of reinforced concrete members using bonded steel plates is an effective, convenient and economic method of improving structural performance. However, disadvantages inherent in the use of steel have stimulated research into the possibility of using fibre reinforced polymer (FRP) materials in its place, providing a non-corrosive, more versatile strengthening system. This book presents a detailed study of the flexural strengthening of reinforced and prestressed concrete members using fibre reinforced polymer composite plates. It is based to a large extent on material developed or provided by the consortium which studied the technology of plate bonding to upgrade structural units using carbon fibre / polymer composite materials. The research and trial tests were undertaken as part of the ROBUST project, one of several ventures in the UK Government's DTI-LINK Structural Composites Programme. The book has been designed for practising structural and civil engineers seeking to understand the principles and design technology of plate bonding, and for final year undergraduate and postgraduate engineers studying the principles of highway and bridge engineering and structural engineering. Detailed study of the flexural strengthening of reinforced and prestressed concrete members using fibre reinforced polymer composites Contains in-depth case histories

Design of FRP and Steel Plated RC Structures - Deric Oehlers 2004-09-11

There are a large and ever-increasing number of structures and buildings worldwide that are in need of

refurbishment, rehabilitation and strengthening. The retrofitting of beams and slabs for this purpose is now recognized as the most cost-effective and environmentally sustainable method of carrying out this essential renovation work. The authors of Design of FRP and Steel Plated RC Structures are both acknowledged world experts on these techniques and their book has been designed to provide the reader with a comprehensive overview of the established techniques and their applications as well as thorough coverage of newly emerging methodologies and their uses. The comparison of FRP and steel is a particular focus and the authors provide practical examples of where one material might be used in preference to another. Indeed practical, worked examples of how, when, and why specific solutions have been chosen in real-world situations are used throughout the text and provide the user with invaluable insights into the decision-making process and its technical background. Just as importantly these examples make the understanding and application of these techniques easier to understand for the student and the practitioner. The book is international in appeal, as while no reference is made to specific local codes the authors' approach always follows that of the more advanced structural codes worldwide. As such it will remain an essential resource for many years to come. Design of FRP and Steel Plated RC Structures is an important reference for a broad range of researchers, students and practitioners including civil engineers and contractors, architects, designers and builders. Contains detailed worked examples throughout to aid understanding and provide technical insight Covers all types of metal plates and all types of FRP plates Uses design philosophies that can be used with any mathematical model Provides coverage of all main international guidelines [ACI 440. 2R-17 Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures](#) - ACI Committee 440 2017-04-27

Reinforced Concrete with FRP Bars Antonio Nanni 2014-03-05

Corrosion-resistant, electromagnetic transparent and lightweight fiber-reinforced polymers (FRPs) are accepted as valid alternatives to steel in concrete reinforcement. Reinforced Concrete with FRP Bars: Mechanics and Design, a technical guide based on the authors' more than 30 years of collective experience, provides principles, algorithms, and practical examples. Well-illustrated with case studies on flexural and column-type members, the book covers internal, non-prestressed FRP reinforcement. It assumes some familiarity with reinforced concrete, and excludes prestressing and near-surface mounted reinforcement applications. The text discusses FRP materials properties, and addresses testing and quality control, durability, and serviceability. It provides a historical overview, and emphasizes the ACI technical literature along with other research worldwide. Includes an explanation of the key physical mechanical properties of FRP bars and their production methods Provides algorithms that govern design and detailing, including a new formulation for the use of FRP bars in columns Offers a justification for the development of strength reduction factors based on reliability considerations Uses a two -story building solved in Mathcad® that can become a template for real projects This book is mainly intended for practitioners and focuses on the fundamentals of performance and design of concrete members with FRP reinforcement and reinforcement detailing. Graduate students and researchers can use it as a valuable resource. Antonio Nanni is a professor at the University of Miami and the University of Naples Federico II. Antonio De Luca and Hany Zadeh are consultant design engineers.

Strengthening Design of Reinforced Concrete with FRP - Hayder A. Rasheed 2014-12-16

Strengthening Design of Reinforced Concrete with FRP establishes the art and science of strengthening design of reinforced concrete with fiber-reinforced polymer (FRP) beyond the abstract nature of the design guidelines from Canada (ISIS Canada 2001), Europe (FIB Task Group 9.3 2001), and the United States (ACI 440.2R-08). Evolved from thorough class notes used to teach a graduate course at Kansas State University, this comprehensive textbook: Addresses material characterization, flexural strengthening of beams and slabs, shear strengthening of beams, and confinement strengthening of columns Discusses the installation and inspection of FRP as externally bonded (EB) or near-surface-mounted (NSM) composite systems for concrete members Contains shear design examples and design examples for each flexural failure mode independently, with comparisons to actual experimental capacity Presents innovative design aids based on ACI 440 code provisions and hand calculations for confinement design interaction diagrams of columns Includes extensive end-of-chapter questions, references for further study, and a solutions manual with qualifying course adoption Delivering a detailed introduction to FRP strengthening design, Strengthening Design of Reinforced Concrete with FRP offers a depth of coverage ideal for senior-level undergraduate, master's-level, and doctoral-level graduate civil engineering courses.

FRP Composites for Reinforced and Prestressed Concrete Structures - Perumalsamy Balaguru
2008-11-05

High strength fibre composites (FRPs) have been used with civil structures since the 1980s, mostly in the repair, strengthening and retrofitting of concrete structures. This has attracted considerable research, and the industry has expanded exponentially in the last decade. Design guidelines have been developed by professional organizations in a number of countries including USA, Japan, Europe and China, but until now designers have had no publication which provides practical guidance or accessible coverage of the fundamentals. This book fills this void. It deals with the fundamentals of composites, and basic design principles, and provides step-by-step guidelines for design. Its main theme is the repair and retrofit of un-reinforced, reinforced and prestressed concrete structures using carbon, glass and other high strength fibre composites. In the case of beams, the focus is on their strengthening for flexure and shear or their stiffening. The main interest with columns is the improvement of their ductility; and both strengthening and ductility improvement of un-reinforced structures are covered. Methods for evaluating the strengthened structures are presented. Step by step procedures are set out, including flow charts, for the various structural components, and design examples and practice problems are used to illustrate. As infrastructure ages worldwide, and its demolition and replacement becomes less of an option, the need for repair and retrofit of existing facilities will increase. Besides its audience of design professionals, this book suits graduate and advanced undergraduate students.

Seismic Design of Reinforced and Precast Concrete Buildings - Robert E. Englekirk 2003-03-10

* Presents the basics of seismic-resistant design of concrete structures. * Provides a major focus on the seismic design of precast bracing systems.

Design Procedures for the Use of Composites in Strengthening of Reinforced Concrete Structures
- Carlo Pellegrino 2015-09-11

This book analyses the current knowledge on structural behaviour of RC elements and structures strengthened with composite materials (experimental, analytical and numerical approaches for EBR and NSM), particularly in relation to the above topics, and the comparison of the predictions of the current available codes/recommendations/guidelines with selected experimental results. The book shows possible critical issues (discrepancies, lacunae, relevant parameters, test procedures, etc.) related to current code predictions or to evaluate their reliability, in order to develop more uniform methods and basic rules for design and control of FRP strengthened RC structures. General problems/critical issues are clarified on the basis of the actual experiences, detect discrepancies in existing codes, lacunae in knowledge and, concerning these identified subjects, provide proposals for improvements. The book will help to contribute to promote and consolidate a more qualified and conscious approach towards rehabilitation and strengthening existing RC structures with composites and their possible monitoring.

Fibre-Reinforced Polymer Reinforcement for Concrete Structures - Kiang Hwee Tan 2003

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.

Developments in Fiber-Reinforced Polymer (FRP) Composites for Civil Engineering - Nasim Uddin
2013-05-15

The use of fiber-reinforced polymer (FRP) composite materials has had a dramatic impact on civil engineering techniques over the past three decades. FRPs are an ideal material for structural applications where high strength-to-weight and stiffness-to-weight ratios are required. Developments in fiber-reinforced polymer (FRP) composites for civil engineering outlines the latest developments in fiber-reinforced polymer (FRP) composites and their applications in civil engineering. Part one outlines the general developments of fiber-reinforced polymer (FRP) use, reviewing recent advancements in the design and processing techniques of composite materials. Part two outlines particular types of fiber-reinforced polymers and covers their use in a wide range of civil engineering and structural applications, including their use in disaster-resistant buildings, strengthening steel structures and bridge superstructures. With its distinguished editor and international team of contributors, Developments in fiber-reinforced polymer (FRP) composites for civil engineering is an essential text for researchers and engineers in the field of civil engineering and industries such as bridge and building construction. Outlines the latest developments in fiber-reinforced polymer composites and their applications in civil engineering Reviews recent advancements in the design and processing techniques of composite materials Covers the use of particular types of fiber-reinforced polymers in a wide range of civil engineering and structural applications

Fiber-Reinforced-Plastic (FRP) Reinforcement for Concrete Structures - David A Hensher
2016-01-22

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 International Handbook of FRP Composites in Civil Engineering - Manoochehr Zoghi
2013-09-26

Fiber-reinforced polymer (FRP) composites have become an integral part of the construction industry because of their versatility, enhanced durability and resistance to fatigue and corrosion, high strength-to-weight ratio, accelerated construction, and lower maintenance and life-cycle costs. Advanced FRP composite materials are also emerging for a wide range of civil infrastructure applications. These include everything from bridge decks, bridge strengthening and repairs, and seismic retrofit to marine waterfront structures and sustainable, energy-efficient housing. The International Handbook of FRP Composites in Civil Engineering brings together a wealth of information on advances in materials, techniques, practices, nondestructive testing, and structural health monitoring of FRP composites, specifically for civil infrastructure. With a focus on professional applications, the handbook supplies design guidelines and standards of practice from around the world. It also includes helpful design formulas, tables, and charts to provide immediate answers to common questions. Organized into seven parts, the handbook covers: FRP fundamentals, including history, codes and standards, manufacturing, materials, mechanics, and life-cycle costs Bridge deck applications and the critical topic of connection design for FRP structural members External reinforcement for rehabilitation, including the strengthening of reinforced concrete, masonry,

wood, and metallic structures FRP composites for the reinforcement of concrete structures, including material characteristics, design procedures, and quality assurance-quality control (QA/QC) issues Hybrid FRP composite systems, with an emphasis on design, construction, QA/QC, and repair Quality control, quality assurance, and evaluation using nondestructive testing, and in-service monitoring using structural health monitoring of FRP composites, including smart composites that can actively sense and respond to the environment and internal states FRP-related books, journals, conference proceedings, organizations, and research sources Comprehensive yet concise, this is an invaluable reference for practicing engineers and construction professionals, as well as researchers and students. It offers ready-to-use information on how FRP composites can be more effectively utilized in new construction, repair and reconstruction, and architectural engineering.

Reinforced Concrete Design with FRP Composites - B. V. GangaRao 2006-11-20

Although the use of composites has increased in many industrial, commercial, medical, and defense applications, there is a lack of technical literature that examines composites in conjunction with concrete construction. Fulfilling the need for a comprehensive, explicit guide, Reinforced Concrete Design with FRP Composites presents specific informat

Fiber Reinforced Polymers - Martin Masuelli 2013-01-23

Fiber Reinforced Polymers are by no means new to this world. It is only because of our fascination with petrochemical and non-petrochemical products that these wonderful materials exist. In fact, the polymers can be considered and used in the construction and construction repair. The petrochemical polymers are of low cost and are used more than natural materials. The Fiber Reinforced Polymers research is currently increasing and entails a quickly expanding field due to the vast range of both traditional and special applications in accordance to their characteristics and properties. Fiber Reinforced Polymers are related to the improvement of environmental parameters, consist of important areas of research demonstrating high potential and particularly great interest, as civil construction and concrete repair.

Strengthening of Concrete Structures Using Fiber Reinforced Polymers (FRP) - Hwai-Chung Wu 2017-02-21

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

Composites for Construction - Lawrence C. Bank 2006-07-21

The first textbook on the design of FRP for structural engineering applications Composites for Construction is a one-of-a-kind guide to understanding fiber-reinforced polymers (FRP) and designing and retrofitting structures with FRP. Written and organized like traditional textbooks on steel, concrete, and wood design, it demystifies FRP composites and demonstrates how both new and retrofit construction projects can especially benefit from these materials, such as offshore and waterfront structures, bridges, parking garages, cooling towers, and industrial buildings. The code-based design guidelines featured in this book allow for demonstrated applications to immediately be implemented in the real world. Covered codes and design guidelines include ACI 440, ASCE Structural Plastics Design Manual, EUROCOMP Design Code,

AASHTO Specifications, and manufacturer-published design guides. Procedures are provided to the structural designer on how to use this combination of code-like documents to design with FRP profiles. In four convenient sections, Composites for Construction covers: * An introduction to FRP applications, products and properties, and to the methods of obtaining the characteristic properties of FRP materials for use in structural design * The design of concrete structural members reinforced with FRP reinforcing bars * Design of FRP strengthening systems such as strips, sheets, and fabrics for upgrading the strength and ductility of reinforced concrete structural members * The design of trusses and frames made entirely of FRP structural profiles produced by the pultrusion process

Non-Metallic (FRP) Reinforcement for Concrete Structures - L. Taerwe 2004-06-02

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.

Textile Reinforced Cement Composites - Jan Wastiels 2020-03-05

This Special Issue presents the latest advances in the field of Textile-Reinforced Cement Composites, including Textile-Reinforced Concrete (TRC), Textile-Reinforced Mortar (TRM), Fabric-Reinforced Cementitious Matrix (FRCM), etc. These composite materials distinguish themselves from other fibre-reinforced concrete materials by their strain-hardening behaviour under tensile loading. This Special Issue is composed of 14 papers covering new insights in structural and material engineering. The papers include investigations on the level of the fibre reinforcement system as well as on the level of the composites, investigating their impact and fatigue behaviour, durability and fire behaviour. Both the strengthening of existing structures and the development of new structural systems such as lightweight sandwich systems are presented, and analysis and design methods are discussed. This Special Issue demonstrates the broadness and intensity of the ongoing advancements in the field of Textile-Reinforced Cement composites and the importance of several future research directions.

FRP - J. G. Teng 2002

The strengthening of reinforced concrete (RC) structures using advanced fibre-reinforced polymer (FRP) composites, and in particular the behaviour of FRP-strengthened RC structures is a topic which has become very popular in recent years. This popularity has arisen due to the need to maintain and upgrade essential infrastructure in all parts of the world, combined with the well-known advantages of FRP composites, such as good corrosion resistance and ease for site handling due to their light weight. The continuous reduction in the material cost of FRP composites has also contributed to their popularity. While a great amount of research now exists in the published literature on this topic, it is scattered in various journals and conference proceedings. This book therefore provides the first ever comprehensive, state-of-the-art summary of the existing research on FRP strengthening of RC structures, with the emphasis being on structural behaviour and strength models. The main topics covered include: * bond behaviour * flexural and shear strengthening of beams * column strengthening * flexural strengthening of slabs. For each area, the methods of strengthening are discussed, followed by a description of behaviour and failure modes and then the presentation of rational design recommendations, for direct use in practical design of FRP strengthening measures. Researchers, practicing engineers, code writers and postgraduate students in structural engineering and construction materials, as well as consulting firms, government departments, professional bodies, contracting firms and FRP material suppliers will find this an invaluable resource.

Computational Structural Engineering - Yong Yuan 2009-06-05

Following the great progress made in computing technology, both in computer and programming technology, computation has become one of the most powerful tools for researchers and practicing engineers. It has led to tremendous achievements in computer-based structural engineering and there is evidence that current developments will even accelerate in the near future. To acknowledge this trend, Tongji University, Vienna University of Technology, and Chinese Academy of Engineering, co-organized the International Symposium on Computational Structural Engineering 2009 in Shanghai (CSE'09). CSE'09 aimed at providing a forum for presentation and discussion of state-of-the-art development in scientific computing applied to engineering sciences. Emphasis was given to basic methodologies, scientific development and engineering applications. Therefore, it became a central academic activity of the Inter-

tional Association for Computational Mechanics (IACM), the European Community on Computational Methods in Applied Sciences (ECCOMAS), The Chinese Society of Theoretical and Applied Mechanics, the China Civil Engineering Society, and the Architectural Society of China. A total of 10 invited papers, and around 140 contributed papers were presented in the proceedings of the symposium. Contributors of papers came from 20 countries around the world and covered a wide spectrum related to the computational structural engineering.

Structural Rehabilitation Using Advanced Composites - Steven J. Foubert 2014-08-09

Composites in Construction, a Reality - Edoardo Cosenza 2002

This collection contains 29 papers presented at an international workshop, held in Capri, Italy, July 20-21, 2001.

Rehabilitation of Concrete Structures with Fiber-Reinforced Polymer - Rajendra Mahaidi 2018-11-12

Rehabilitation of Concrete Structures with Fiber Reinforced Polymer is a complete guide to the use of FRP in flexural, shear and axial strengthening of concrete structures. Through worked design examples, the authors guide readers through the details of usage, including anchorage systems, different materials and methods of repairing concrete structures using these techniques. Topics include the usage of FRP in concrete structure repair, concrete structural deterioration and rehabilitation, methods of structural rehabilitation and strengthening, a review of the design basis for FRP systems, including strengthening limits, fire endurance, and environmental considerations. In addition, readers will find sections on the strengthening of members under flexural stress, including failure modes, design procedures, examples and anchorage detailing, and sections on shear and torsion stress, axial strengthening, the installation of FRP systems, and strengthening against extreme loads, such as earthquakes and fire, amongst other important topics. Presents worked design examples covering flexural, shear, and axial strengthening Includes complete coverage of FRP in Concrete Repair Explores the most recent guidelines (ACI440.2, 2017; AS5100.8, 2017 and Concrete society technical report no. 55, 2012)

FRP Composites - S. S. J. Moy 2001

- 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 of Concrete Structures Using Fiber Reinforced Polymers (FRP) - Hwai Chung Wu 2017-03-01

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

Facing the Challenges in Structural Engineering - Hugo Rodrigues 2017-07-11

This edited volume brings together findings and case studies on fundamental and applied aspects of structural engineering, applied to buildings, bridges and infrastructures in general. It focuses on the application of advanced experimental and numerical techniques and new technologies to the built environment. This volume is part of the proceedings of the 1st GeoMEast International Congress and Exhibition on Sustainable Civil Infrastructures, Egypt 2017.

FRP Composites for Reinforced and Prestressed Concrete Structures - Parasuramsamy Balaguru 2014-04-21

High strength fibre composites (FRPs) have been used with civil structures since the 1980s, mostly in the repair, strengthening and retrofitting of concrete structures. This has attracted considerable research, and the industry has expanded exponentially in the last decade. Design guidelines have been developed by professional organizations in a number of countries including USA, Japan, Europe and China, but until now designers have had no publication which provides practical guidance or accessible coverage of the fundamentals. This book fills this void. It deals with the fundamentals of composites, and basic design principles, and provides step-by-step guidelines for design. Its main theme is the repair and retrofit of unreinforced, reinforced and prestressed concrete structures using carbon, glass and other high strength fibre composites. In the case of beams, the focus is on their strengthening for flexure and shear or their stiffening. The main interest with columns is the improvement of their ductility; and both strengthening and ductility improvement of unreinforced structures are covered. Methods for evaluating the strengthened structures are presented. Step by step procedures are set out, including flow charts, for the various structural components, and design examples and practice problems are used to illustrate. As infrastructure ages worldwide, and its demolition and replacement becomes less of an option, the need for repair and retrofit of existing facilities will increase. Besides its audience of design professionals, this book suits graduate and advanced undergraduate students.

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Guide for the Design and Construction of Concrete Reinforced with FRP Bars - ACI Committee 440 2001

Analysis and Design of FRP Reinforced Concrete Structures - Shamsheer Bahadur Singh 2015-02-05

The Most Complete FRP Reinforced Concrete Structure Analysis and Design Guide This comprehensive reference provides proven design procedures for the use of fiber-reinforced polymer (FRP) materials for

reinforcement, prestressing, and strengthening of reinforced concrete structures. The characteristics of FRP composite materials as well as the latest manufacturing techniques are discussed. Detailed illustrations and tables, design equations, end-of-chapter problems, and real-world case studies are included in this authoritative resource. Analysis and Design of FRP Reinforced Concrete Structures covers: Material characteristics of FRP bars History and uses of FRP technology Design of RC structures reinforced with FRP bars Design philosophy for FRP external strengthening systems Durability-based design approach for external FRP strengthening of RC beams

Design of FRP Systems for Strengthening Concrete Girders in Shear - Abdeldjelil Belarbi 2011

TRB's National Cooperative Highway Research Program (NCHRP) Report 678: Design of FRP Systems for Strengthening Concrete Girders in Shear offers suggested design guidelines for concrete girders strengthened in shear using externally bonded Fiber-Reinforced Polymer (FRP) systems. The guidelines address the strengthening schemes and application of the FRP systems and their contribution to shear capacity of reinforced and prestressed concrete girders. The guidelines are supplemented by design examples to illustrate their use for concrete beams strengthened with different FRP systems. Appendix A of NCHRP Report 678, which contains the research agency's final report, provides further elaboration on the work performed in this project. Appendix A: Research Description and Findings, is only available online.

Strengthening and Rehabilitation of Civil Infrastructures Using Fibre-Reinforced Polymer (FRP) Composites - L C Hollaway 2008-07-18

The repair of deteriorated, damaged and substandard civil infrastructures has become one of the most important issues for the civil engineer worldwide. This important book discusses the use of externally-bonded fibre-reinforced polymer (FRP) composites to strengthen, rehabilitate and retrofit civil engineering structures, covering such aspects as material behaviour, structural design and quality assurance. The first three chapters of the book review structurally-deficient civil engineering infrastructure, including concrete, metallic, masonry and timber structures. FRP composites used in rehabilitation and surface preparation of the component materials are also reviewed. The next four chapters deal with the design of FRP systems for the flexural and shear strengthening of reinforced concrete (RC) beams and the strengthening of RC columns. The following two chapters examine the strengthening of metallic and masonry structures with FRP composites. The last four chapters of the book are devoted to practical considerations in the flexural strengthening of beams with unstressed and prestressed FRP plates, durability of externally bonded FRP composite systems, quality assurance and control, maintenance, repair, and case studies. With its distinguished editors and international team of contributors, Strengthening and rehabilitation of civil infrastructures using fibre-reinforced polymer (FRP) composites is a valuable reference guide for engineers, scientists and technical personnel in civil and structural engineering working on the rehabilitation and strengthening of the civil infrastructure. Reviews the use of fibre-reinforced polymer (FRP) composites in structurally damaged and sub-standard civil engineering structures Examines the role and benefits of fibre-reinforced polymer (FRP) composites in different types of structures such as masonry and metallic strengthening Covers practical considerations including material behaviour, structural design and quality assurance

Structures Strengthened with Bonded Composites - Zhishen Wu 2020-07-15

Structures Strengthened with Bonded Composites presents a comprehensive resource on the strengthening of concrete, reinforced and prestressed concrete, masonry, steel and other composite structures using externally-bonded FRP composites. The book emphasizes a systematic and fundamental investigation on bonding and debonding behavior of the FRP-concrete interface and structural performances of FRP-strengthened structures with a combination of experimental, theoretical and numerical studies. This book will appeal to all those concerned with strengthening and retrofitting of existing structures from the effect of additional anticipated loads in the civil sector. Discusses the FRP strengthening of different types of structures, including bridges, tunnels, buildings, historic structures and underwater constructions Establishes a systematic theory on interfacial fracture mechanics and clarifies different debonding mechanisms Describes design methods and makes comparison of design considerations and methods among different countries Presents temperature and fatigue effects and long-term behavior for different strengthening methods

Design Procedures for the Use of Composites in Strengthening of Reinforced Concrete Structures Pellegrino 2015-08-25

This book analyses the current knowledge on structural behaviour of RC elements and structures strengthened with composite materials (experimental, analytical and numerical approaches for EBR and NSM), particularly in relation to the above topics, and the comparison of the predictions of the current available codes/recommendations/guidelines with selected experimental results. The book shows possible critical issues (discrepancies, lacunae, relevant parameters, test procedures, etc.) related to current code predictions or to evaluate their reliability, in order to develop more uniform methods and basic rules for design and control of FRP strengthened RC structures. General problems/critical issues are clarified on the basis of the actual experiences, detect discrepancies in existing codes, lacunae in knowledge and, concerning these identified subjects, provide proposals for improvements. The book will help to contribute to promote and consolidate a more qualified and conscious approach towards rehabilitation and strengthening existing RC structures with composites and their possible monitoring.

10th International Conference on FRP Composites in Civil Engineering - Alper Ilki 2021-11-26

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.

Externally Bonded FRP Reinforcement for RC Structures - fib Fédération internationale du béton 2001-01-01

In December 1996, the then CEB established a Task Group with the main objective to elaborate design guidelines for the use of FRP reinforcement in accordance with the design format of the CEB-FIP Model Code and Eurocode2. With the merger of CEB and FIP into fib in 1998, this Task Group became fib TG 9.3 FRP Reinforcement for concrete structures in Commission 9 Reinforcing and Prestressing Materials and Systems. The Task Group consists of about 60 members, representing most European universities, research institutes and industrial companies working in the field of advanced composite reinforcement for concrete structures, as well as corresponding members from Canada, Japan and USA. Meetings are held twice a year and on the research level its work is supported by the EU TMR (European Union Training and Mobility of Researchers) Network "ConFibreCrete". The work of fib TG 9.3 is performed by five working parties (WP): Material Testing and Characterization (MT&C) Reinforced Concrete (RC) Prestressed Concrete (PC) Externally Bonded Reinforcement (EBR) Marketing and Applications (M&A) This technical report constitutes the work conducted as of to date by the EBR party. This bulletin gives detailed design guidelines on the use of FRP EBR, the practical execution and the quality control, based on the current expertise and state-of-the-art knowledge of the task group members. It is regarded as a progress report since it is not the aim of this report to cover all aspects of RC strengthening with composites. Instead, it focuses on those aspects that form the majority of the design problems. several of the topics presented are subject of ongoing research and development, and the details of some modelling approaches may be subject to future revisions. as knowledge in this field is advancing rapidly, the work of the EBR WP will continue. In spite of this limit in scope, considerable effort has been made to present a bulletin that is today's state-of-art in the area of strengthening of concrete structures by means of externally bonded FRP reinforcement.

Strengthening of Reinforced Concrete Structures - Len C. Hollaway 1999-04-09

The in situ rehabilitation or upgrading of reinforced concrete members using bonded steel plates is an effective, convenient, and economic method of improving structural performance. However, disadvantages inherent in the use of steel have stimulated research into using fiber reinforced polymer (FRP) material in

its place, with the goal of providing a non-corrosive, more versatile strengthening system. Strengthening of Reinforced Concrete Structures presents a detailed study of the flexural strengthening of reinforced and prestressed concrete members using FRP composite plates. This book covers short and long term performance through model and full-scale experimental testing plus theoretical and numerical considerations. It discusses previous investigative and site work undertaken to strengthen concrete beams using steel bonded plates and the pros and cons of using the steel and composite plate materials. It also presents case histories of construction members upgraded or strengthened using carbon fibre/polymer matrix composite materials bonded to the structural unit. A consortium of academic and industrial researchers provided much of the data and contributed the chapters to this volume. The research and trial

tests were undertaken as part of the United Kingdom's ROBUST project. Strengthening of Reinforced Concrete Structures serves to disseminate the large amount of information that resulted from these studies. As detailed in this book, their results will serve to help generate and formulate design specifications as engineers continue to apply these important techniques to an ever-widening range of applications.

FRP-Strengthened Metallic Structures - Xiao-Ling Zhao 2013-09-13

Repairing or strengthening failing metallic structures traditionally involves using bulky and heavy external steel plates that often pose their own problems. The plates are generally prone to corrosion and overall fatigue. Fiber-reinforced polymer (FRP), a composite material made of a polymer matrix reinforced with fibers, offers a great alternative