Frp Composites In Civil Engineering Book

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.

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

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 chapter first reviews current structural applications of fiber-reinforced polymer (FRP) composites in bridge structures, and describes advantages of FRP in bridge applications. This chapter then introduces the design of a hybrid FRP-concrete bridge superstructure, which has been developed at The University at Buffalo for the past ten years, and discusses structural performance of the superstructure based on extensive experimental and analytical studies.

Modern structural applications of composite materials are dictated by the processing methods available. In this chapter, we introduce recent developments related to the manufacturing of composites in civil engineering applications using vacuum assisted resin transfer molding, pultrusion, and automated fiber placement.

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.

Chapters 16 and discuss the development of the advanced polymer composite material applications in bridge engineering. They demonstrate the innovative types of components and structures which have been developed from FRP composite materials and the most advantageous way to employ composites in bridge engineering. Given the importance
of bridge infrastructure, the discussion of this topic has been split over two chapters. This chapter focuses on the type of FRP composite materials used in bridge engineering, their in-service properties and their applications in bridge enclosures and the rehabilitation of reinforced and prestressed concrete bridge beams and columns. covers rehabilitation of metallic bridge structures, all FRP composite bridges and bridges built with hybrid systems. 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 to gain the ability to accurately predict the long-term durability of the FRP–concrete interface. 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.

This chapter continues the discussions of the development of advanced polymer composite material applications
associated with bridge engineering. It focuses on the rehabilitation of metallic bridge structures, all-FRP composite bridges and bridges built with hybrid systems. covered the materials used in FRP composites, in-service properties and applications of FRP composites in bridge enclosures, the rehabilitation of reinforced and prestressed concrete bridge beams and columns.
This text teaches readers how to analyse and design with fiber reinforced polymers (FRP) for civil engineering applications. It demystifies FRP composites and demonstrates applications where their properties make them ideal materials to consider off-shore and waterfront structures, factories, and storage tanks.
Modular panelized construction is a modern form of construction technique in which precast multifunctional structural panels are used. In this technique, precast panels are fabricated in the manufacturing facility and are transported to the construction site. Traditional structural insulated panels (SIPs) consist of oriented strand boards (OSB) as facesheets and expanded polystyrene (EPS) foam as the core. These panels are highly energy efficient but have issues in terms of poor impact resistance and higher life cycle costs. Proposed panels consist of E-glass/polypropylene (PP) laminates as facesheets and EPS foam as core and are called composite structural insulated panels (CSIPs). Proposed CSIPs overcome the issues of traditional SIPs and retain all the energy-saving benefits of the traditional SIPs. This chapter describes manufacturing techniques developed for CSIPs and connection details for bonding CSIPs on the construction site. Based on the experimental investigation, ultrasonic welding was found to be the most suitable technique for joining the proposed CSIPs.
"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 (IIFC). 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.
This chapter deals with the uses of advanced composite materials in the construction industry. After considering the advantages of using composites and methods of fabrication, it outlines the surprisingly wide range of applications of composites. Examples are given from around the world of components and complete buildings and bridges, railway and other infrastructure, geotechnical applications and pipes for the water sector. Finally a number of more unusual or future
possibilities are presented.

Abstract: The primary objective of this chapter is first to introduce and demonstrate the application of thermoplastic (woven glass reinforced polypropylene) in the design of modular fiber-reinforced bridge decks, and next the development of jackets for confining concrete columns against compression and impact loading. The design concept and manufacturing processes of the thermoplastic bridge deck composite structural system are presented by recognizing the structural demands required to support highway traffic. Then the results of the small-scale static cylinder tests and the impact tests of concrete columns are presented, demonstrating that thermoplastic reinforcement jackets act to restrain the lateral expansion of the concrete that accompanies the onset of crushing, maintaining the integrity of the core concrete, and enabling much higher compression strains (compared to CFRP composite wraps) to be sustained by the compression zone before failure occurs.

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 reinforces 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 composite plates. Contains in-depth case histories.

In fiber reinforced plastics (FRP), as a special type of polymer matrix composite, fibers provide the stiffness and strength while the surrounding plastic matrix transfers the stress between fibers and protects them. In this chapter, the role of fibers in FRP is delineated, their types and properties are discussed and the fabric forms in which they can be formed and used to reinforce FRP are presented. A special focus is given to the effect of the chemical structure of fibers on the stability and the level of anisotropy of their mechanical response. Furthermore, the effect of assembling these fibers into yarns and fabrics on the response of the FRP is presented as basis for further readings.

This chapter presents a systematic approach for material characterization, analysis, and design of all-fiber-reinforced
polymer or plastic (FRP) composite structures. The suggested ‘bottom-up’ analysis concept is applied throughout the procedure, from materials/microstructures, to macro components, to structural members, and finally to structural systems, thus providing a systematic analysis methodology for all-FRP composite structures. The systematic approach described in this chapter can be used efficiently to analyze and design FRP shapes and bridge systems and also develop new design concepts for all composite structures.

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

This chapter discusses the use of vinylester resin as a matrix in polymer composite materials to be used in civil engineering applications. The chapter begins by discussing the increasing trend of composite development and use in civil engineering along with the related reasons. It then reviews the chemistry of vinylester resins together with their mechanical and chemical properties as well as the applications of vinylester resin and composites in the construction industry. The chapter includes indications on future applications of vinylester-based fibre-reinforced composites along with a section devoted to sources of further and relevant information.

This chapter focuses on the properties, manufacturing processes and quality control of pultruded advanced composites
used in civil engineering applications. Pultrusion technology is first briefly explained, with the main features of the raw materials used being introduced, and the philosophy underlying the development of pultruded advanced composites discussed. A detailed description of the pultrusion process then follows, covering the equipment and procedure, technical specifications and quality control. Subsequently, the types, properties, applications and sustainability of pultruded profiles, reinforcing bars and strengthening strips are described. The final part of the chapter discusses future trends for the pultrusion of the advanced composites used in civil engineering applications.

This chapter summarizes the recent advances in the use of fiber-reinforced polymer (FRP) materials for repair, rehabilitation, and strengthening of steel structures. Conventional methods of strengthening and repairing steel structures are presented. The advantages and limitations of using FRP materials are summarized. Topics presented include strengthening of flexural members, strengthening with prestressed FRP materials, stress-based and fracture mechanics-based approaches to evaluating bond behavior, repair of cracked steel members, and strengthening of slender members subjected to compression forces. The chapter concludes with a brief discussion of future trends in this field and a summary of other resources for further information.

High-quality and expedient repair methods are necessary to address concrete deterioration that can occur in bridge structures. Most infrastructure-related applications of fiber-reinforced plastics (FRPs) use hand layup methods. Hand layup is tedious, labor-intensive and results are sensitive to personnel skill level. An alternative method of FRP application is vacuum assisted resin transfer molding (VARTM). VARTM uses single-sided molding technology to infuse resin over fabrics wrapping large structures, such as bridge girders and columns. There is no research currently available on the interface developed, when VARTM processing is adopted to wrap fibers such as carbon and/or glass over concrete structures. This chapter investigates the shear and flexural strength gains of a beam by carbon fiber cast on concrete using the VARTM method. The carbon fiber composite was made using Sikadur HEX 103C and low viscosity epoxy resin Sikadur 300. Tests were conducted to determine and document the gains of FRP rehabilitated beams applied by the VARTM method compared to the hand layup method of application. This newly introduced technique to repair and retrofit a simple span I-565 prestressed concrete bridge girder in Huntsville, Alabama, was implemented in the field within two days without any traffic interruption, and the field demonstration of this newly introduced technique to civil infrastructure is presented to the end.

Fiber-reinforced polymer (FRP) composite materials have been increasingly used in civil engineering applications in the past two decades. Their wide ranging use, however, is still not realized due to a few fundamental issues including high material costs, relatively short history of applications and the gaps in the development of established standards. Design safety requires that all possible modes and mechanisms of failure are identified, characterized, and accounted for in the design procedures. This chapter provides a review of the failure types encountered in structural engineering applications of FRP and the preventive methods and strategies that have been developed to eliminate or delay such failures. As part of preventive measures, various non-destructive testing (NDT) and structural health monitoring (SHM) methods used for monitoring FRP applications are discussed with illustrative examples.

The low velocity impact response of plain autoclaved aerated concrete (AAC) and FRP/AAC sandwich panels has been investigated. The structural sandwich panels composed of a FRP/AAC combination have shown excellent characteristics in terms of high strength and high stiffness-to-weight ratios. In addition to having adequate flexural and shear properties, the behavior of FRP/AAC sandwich panels needs to
be investigated when subjected to impact loading. During service, the structural members in the building structures are subjected to impact loading that varies from object-caused impact, blast due to explosions, to high velocity impact of debris during tornados, hurricanes, or storms. Low velocity impact (LVI) testing serves as a means to quantify the allowable impact energy that the structure is able to withstand and to assess the typical failure modes encountered during this type of loading. The objectives of this chapter are: to study the response of plain AAC and CFRP/AAC sandwich structures to low velocity impact and to assess the damage performance of the panels; to study the effect of FRP laminates on the impact response of CFRP/AAC panels; to study the effect of the processing method (hand layup versus VARTM) and panel stiffness on the impact response of the hybrid panels. Impact testing was conducted using an Instron drop-tower testing machine. Experimental results showed a significant influence of CFRPs laminates on the energy absorbed and peak load of the CFRP/AAC panels. Further, a theoretical analysis was conducted to predict the energy absorbed by the CFRP/AAC sandwich panel using the energy balance model, and the results found were in good accordance with the experimental ones.

Portland cement concrete is a brittle material. The main reason for incorporating fibres into a cement matrix is to improve the cracking deformation characteristics, increasing not only the toughness, impact and tensile strength, but also eliminating temperature and shrinkage cracks. Several different types of fibres have been used to reinforce cement-based materials. This chapter briefly discusses the characteristics of fibre-reinforced concrete (FRC), reporting the effect of the fibres on the physico-chemical and mechanical properties. It also presents some of the recent research and future perspectives of FRC.

This Proceedings contains the papers presented at the International Conference on FRP Composites in Civil Engineering, held in Hong Kong, China, on 12-15 December 2001. The papers, contributed from 24 countries, cover a wide spectrum of topics and demonstrate the recent advances in the application of FRP (Fibre-reinforced polymer) composites in civil engineering, while pointing to future directions of research in this exciting area.

This chapter presents dozens of select environmental engineering applications of fiber-reinforced polymer (FRP) composite materials with emphasis on their environmental benefits, followed by discussions on durability of composites. Significance of design codes and specifications in promoting and advancing the applications of FRP composites is addressed. With ever increasing attention toward a sustainable built environment, FRP composites have potential to be selected as a material of choice because of the performance and design advantages of FRPs.

Fiber-reinforced polymer (FRP) has been a practical alternative construction material for replacing steel in the construction industry for several decades. However, some mechanical weaknesses of FRP are still unresolved, which limit the extensive use of this material in civil infrastructure. In order to mitigate the disadvantage of using FRP, the concept of hybridization is delivered here. The advantages of hybrid structural systems include the cost effectiveness and the ability to optimize the cross section based on material properties of each constituent material. In this chapter, two major applications of hybrid FRP composites are discussed: (1) the internal reinforcement in reinforced concrete (RC) structures, and (2) the cables in long-span cable-stayed bridges. In order to improve the flexural ductility of FRP-reinforced concrete (FRPRC) beam, the additional steel longitudinal reinforcement is proposed such that the hybrid
FRPRC beams contain both FRP and steel reinforcement. In order to improve the vibrational problem in pure FRP cables used in bridge construction, an innovative hybrid FRP cable which can inherently incorporate a smart damper is proposed. The objective of this chapter is to deliver an up-to-date review of hybrid FRP composite structures, including both the industrial practice and the research in academia. The advantages of using hybrid FRP composites for construction will also be described with experimental support. It is hoped that the reader will appreciate the concept of hybridization, which leads to the efficient utilization of all constituent materials in a bonded system.

Biofibers are emerging as a low cost, lightweight and environmentally superior alternative in composites. Generally, different fibers exhibit different properties that are fundamentally important to the resultant composites. This chapter gives an overview of the most common biofibers in biocomposites, covering their sources, types, structure, composition, and properties. Drawbacks of biofibers, such as dimensional instability, moisture absorption, biological, ultraviolet and fire resistance, will be discussed. The chapter will focus on their modifications (physical and chemical methods), matrices based on their petrochemical resources and bio-based, processing of biofiber reinforced plastic composites covering the factors influencing processing (humidity, additives, machinery, processing parameter, fiber content and length), and processing techniques (compounding, compression molding, extrusion, injection molding, pultrusion and others) will be discussed. The properties of the biocomposites based on their mechanical, physical, and biological behavior will also be covered. Lastly, this chapter concludes with recent developments and trends of biocomposites in the near future in civil engineering.

The chapter begins by discussing a new type of sandwich panel called composite structural insulated panels (CSIPs) intended to replace the traditional SIPs that are made of wood-based materials. A detailed analytical modeling procedure is presented in order to determine the global buckling, interfacial tensile stress at facesheet/core debonding, critical wrinkling stress at facesheet/core debonding, equivalent stiffness, and deflection for CSIPs. The proposed models were validated using experimental results that have been conducted on full-scale CSIP walls and floor panels. In order to be used as a hazard-resistant material, a detailed section was presented to show the resistance of CSIP elements to the different types of hazard effects, including impact loading, floodwater effect, fire effect, and windstorm loading.

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
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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

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