Composite Highway Bridge Design

This text provides an introduction to the theory and practice of designing modern highway bridge superstructures. Beginning with the history of bridges, it describes various types of bridge superstructures, materials of construction, bridge loadings, and analysis techniques for various types.

Because of their excellent torsional capacity, box girders are used extensively in modern bridge construction having curved alignments. Applications of most design codes have been limited to bridges where the radius of curvature is much greater than the span length and cross-sectional dimensions. To meet the practical requirements arising during the design process, simple design methods are needed for curved bridges. This paper presents the results of a parametric study on the relative behaviour of curved and straight box-girder bridges and on the development of a simplified design method for the combined longitudinal moment of curved bridges. The combined moment includes the effects of flexure, torsion, and distortion. Three simply supported concrete-steel composite bridge models, including single-cell, twin-cell, and three-cell box girders and subjected to loadings as specified in the Ontario Highway Bridge Design Code, were analyzed using the finite strip method. The parameters considered in the study include types of cross section: types, locations, and magnitudes of loads; span lengths; and radius of curvature. Preliminary analysis of the results suggests that the behaviour of horizontally curved box-girder bridges is dependent of a variety of parameters, but most importantly on the span-to-radius ratio. Empirical relationships for combined longitudinal moment between curved and straight box-girder bridges are also proposed.

A succinct, real-world approach to complete bridge system design and evaluation Load and Resistance Factor Design (LRFD) and Load and Resistance Factor Rating (LRFR) are design and evaluation methods that have replaced or offered alternatives to other traditional methods as the new standards for designing and load-rating U.S. highway bridges. Bridge Design and Evaluation covers complete bridge systems (substructure and superstructure) in one succinct, manageable package. It presents real-world bridge examples demonstrating both their design and evaluation using LRFD and LRFR. Designed for a 3- to 4-credit undergraduate or graduate-level course, it presents the fundamentals of the topic without expanding needlessly into advanced or specialized topics. Important features include: Exclusive focus on LRFD and LRFR Hundreds of photographs and figures of real bridges to connect the theoretical with the practical Design and evaluation examples from real bridges including actual bridge plans and drawings and design methodologies Numerous exercise problems Specific design for a 3- to 4-credit course at the undergraduate or graduate level The only bridge engineering textbook to cover the important topics of bridge evaluation and rating Bridge Design and Evaluation is the most up-to-date and inclusive introduction available for students in civil engineering specializing in structural and transportation engineering.

The Design of a Three Span Continuous Highway Bridge with Composite Concrete-steel Beams
Worked Examples: In Accordance with Eurocodes and the UK National Annexes
Conceptual and Structural Design of Steel and Steel-Concrete Composite Bridges
A study of pretensioned high strength concrete girders in composite highway bridges - laboratory tests
An LRFD Approach

Steel-concrete composite bridges outlines the various forms that modern steel-concrete composite bridges take, from simple beam bridges through to arches and trusses and modern cable-stay forms. The author brings together a wide variety of steel-concrete composite bridge types, many of which have not been covered in any existing book or design guide. Outlined within are emerging technologies such as folded plate webs, double composite action and extra-dosed girders, along with design rules for composite action and examples of their use in a wide variety of practica

Steel-concrete composite bridges shows how to choose the bridge form and design element sizes to enable the production of accurate drawings and also highlights a wide and full range of examples of the design and construction of this bridge type.

Up-to-date coverage of bridge design and analysis—revised to reflect the fifth edition of the AASHTO LRFDspecifications Design of Highway Bridges, Third Edition offers detailedcoverage of engineering basics for the design of short- andmedium-span bridges. Revised to conform with the latest fifthedition of the American Association of State Highway andTransportation Officials (AASHTO) LRFD Bridge DesignSpecifications, it is an excellent engineering resource for bothprofessionals and students. This updated edition has beenreorganized throughout, spreading the material twenty shorter,more focused chapters that make information even easier to find andnavigate. It also features: Expanded coverage of computer modeling, calibration of servicelimit states, rigid method system analysis, and concrete shear Information on key bridge types, selection principles, andaesthetic issues Dozens of worked problems that allow techniques to be appliedto real-world problems and design specifications A new color insert of bridge photographs, including examples ofhistorical and aesthetic significance New coverage of the "green" aspects of recycled steel Se references for further study From gaining a quick familiarity with the AASHTO LRFDspecifications to seeking broader guidance on highway bridgedesign—Design of Highway Bridges is the one-stop, readyreference that puts information at your fingertips, while alsoserving as an excellent study guide and reference for the U.S.Professional Engineering Examination.

A comprehensive guide to bridge design Bridge Design - Concepts and Analysis provides a unique approach, combining the fundamentals of concept design and structural analysis of bridges in a single volume. The book discusses design solutions from the authors' practical experience and provides insights into conceptual design with concrete, steel or composite bridge solutions as alternatives. Key features: Principal design concepts and analysis are dealt with in a unified approach. Execution methods and evolution of the static scheme during construction are dealt with for and composite bridges. Aesthetics and environmental integration of bridges are considered as an issue for concept design. Bridge analysis, including modelling and detail design aspects, is discussed for different bridge typologies and structural materials. Specific design verification aspects are discussed on the basis of present design rules in Eurocodes. The book is an invaluable guide for postgraduate students studying bridge design, bridge designers and structural engineers.

Optimal Design of Composite Highway Bridge Systems
Design of a Precast Prestressed Composite Highway Bridge H20 - S16 - 44 Loading
Steel Bridges
Finite Element Analysis and Design of Steel and Steel-Concrete Composite Bridges
The Fatigue Behaviour of Welded and Bolted Shear Connectors in Composite Highway Bridges

This English translation of the successful French edition presents the conception and design of steel and steel-concrete composite bridges, from simple beam bridges to cable supported structures. The book focuses primarily on road bridges, emphasizing the basis of their conception and the fundamentals that must be considered to assure structural safety and serviceability, as well as highlighting the necessary design checks. The principles are extended in later chapters to railway bridges as well as bridges for pedestrians and cyclists. Particular attention is paid to consideration of the dynamic performance.

Combining a theoretical background with engineering practice, Design of Steel-Concrete Composite Bridges to Eurocodes covers the conceptual and detailed design of composite bridges in accordance with the Eurocodes. Bridge design is strongly based on prescriptive normative rules regarding loads and their combinations, safety factors, material proper

A How-To Guide for Bridge Engineers and Designers Highway Bridge Superstructure Engineering: LRFD Approaches to Design and Analysis provides a detailed discussion of traditional structural design perspectives, and serves as a state-of-the-art resource on the latest design and analysis of highway bridge superstructures. This book is applicable to highway bridges of all construction and material types, and is based on the load and resistance factor design (LRFD) philosophy. It discusses the theory of probability (with an explanation leading to the calibration process and reliability), and includes fully solved design examples of steel, reinforced and prestressed concrete bridge superstructures. It also contains step-by-step calculations for determining the distribution factors for several different types of bridge superstructures (which form the basis of load and resistance design specifications) and can be found in the AASHTO LRFD Bridge Design Specifications. Fully Realize the Basis and Significance of LRFD Specifications Divided into six chapters, this instructive text: Introduces bridge engineering as a discipline of structural design Describes numerous types of highway bridge superstructures systems Presents a detailed discussion of various types of loads that act on bridge superstructures and substructures Discusses the methods of analyses of highway bridge superstructures Includes a detailed discussion of reinforced and prestressed concrete bridges, and slab-steel girder bridges Highway Bridge Superstructure Engineering: LRFD Approaches to Design and Analysis can be used for teaching highway bridge design courses to undergraduate- and graduate-level classes, and as an excellent resource for practicing engineers.

Design Guide for Composite Highway Bridges
Composite Highway Bridge Design
LRFD and LRFR
Innovative Bridge Design Handbook

Developed to comply with the fifth edition of the AASHTO LFRD Bridge Design Specifications [2010]—Simplified LRFD Bridge Design is "How To" use the Specifications book. Most engineering books utilize traditional deductive practices, beginning with in-depth theories and progressing to the application of theories. The inductive method in the book uses alternative approaches, literally teaching backwards. The book introduces topics by presenting specific design examples. Theories can be understood by students because they appear in the text only after specific design examples are presented, establishing the need to know theories. The emphasis of the book is on step-by-step design procedures of highway bridges by the LRFD method, and "How to Use" the AASHTO Specifications to solve design problems. Some of the design examples and practice problems covered include: Load combinations and load factors Strength limit states for superstructure design Design Live Load HL- 93 Un-factored and Factored Design Loads Fatigue Limit State and fatigue life; Service Limit State Number of design lanes Multiple presence factor of live load Dynamic load allowance Distribution of Live Loads per Lane Wind Loads, Earthquake Loads Plastic moment capacity of composite steel-concrete beam LRFR Load Rating Simplified LRFD Bridge Design is a study guide for engineers preparing for the PE examination as well as a classroom text for civil engineering students and a reference for practicing engineers. Eight design examples and three practice problems describe and introduce the use of articles, tables, and figures from the AASHTO LFRD Bridge Design Specifications. Whenever articles, tables, and figures in examples appear throughout the text, AASHTO LRFD specification numbers are also cited, so that users can cross-reference the material.

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, light weight, high strength, reduced maintenance costs, and rapid installation, outweigh their initial in-place material costs when implemented in highway bridge pro

Finite Element Analysis and Design of Steel and Steel-Concrete Composite Bridges, Second Edition is brought fully-up-to-date and provides structural engineers and researchers with detailed modeling techniques for creating robust design models. The book's eight chapters begin with an overview of the various forms of modern steel and steel-concrete composite bridges as well as current design codes (American, British and Eurocodes). This is followed by self-contained chapters concerning: nonlinear material behavior of the bridge components, applied loads and stability of steel and steel–concrete composite bridges, and design of steel and steel–concrete composite bridge components. The book's final chapter focuses on finite element analysis and design of steel-concrete composite bridges with profiled steel sheeting.The book will be a valuable reference source addressing the issues, problems, challenges, and questions on how to design a composite highway steel bridge with profiled steel sheeting as well finite element modeling of the bridge components.

Design of Horizontally Curved Composite Box-girder Bridges
Finite Element Analysis and Design of Steel and Steel–Concrete Composite Bridges
LRFD Approaches to Design and Analysis
Highway Bridge Superstructure Engineering
Bridge Design

Design of Highway Bridges provides a complete introduction to this important area of engineering, with comprehensive coverage of the theory, specifications, and procedures for the design of short- and medium-span bridges. Beginning with an overview of bridge engineering history, the book examines key bridge types, selection principles, and aesthetic considerations. Design issues are then discussed in detail, from limit states and loads to resistance factors and substructure design.

At present, many Canadian bridges are overdue for rehabilitation or replacement. In the case of steel-concrete composite bridges, the shear connection between the concrete deck and the steel girders is a vital element of the bridge system, and has significant impacts on construction time, cost, structural integrity, and durability. The general performance of the shear connectors in these bridges is becoming an increasingly important issue, as existing bridges are used past their intended design lives, and new bridges are being designed with accelerated construction and longer service lives in mind. Welded shear studs are the standard method of shear connection in composite bridge construction, either cast-in-place or concentrated in grouted “shear pockets” in the case of steel-precast applications. The primary disadvantage of using welded shear studs in structures subjected to repeated loading is that they are believed to perform poorly from a fatigue perspective. As a result, design standards in North America require most bridges to have more than double the number of studs needed for ultimate strength purposes. This leads to construction challenges including arduous deck reinforcement placing, and it reduces the economy gained through steel-precast construction by requiring excessive numbers of shear pockets. It is possible that an enhanced understanding of the performance of welded shear studs in composite beams, including system effects, may allow for relaxed design provisions. High strength bolt shear connectors may be a viable alternative to shear studs in some cases, providing greater fatigue resistance due to the absence of welds, and having a higher material strength than conventional welded studs. The work presented herein is aimed at increasing the state-of-understanding of the fatigue behaviour and reliability of welded shear studs in both cast-in-place and precast concrete composite bridge applications, while also presenting the benefits and drawbacks of two alternative high strength bolt shear connection concepts. A laboratory research program carried out at the University of Waterloo featured the testing of eighteen large-scale beam specimens over a period of two years. In addition to the laboratory work completed by the research team, the author used finite element and reliability analysis methods to augment the test results and extend their applicability to full-scale medium span highway bridges. Over sixty stud fatigue failures and four bolt fatigue failures were observed over the course of this study, greatly adding to a dearth of existing test results, and allowing the construction of a statistically meaningful fatigue design curve of the stud detail from beam tests for the first time. System effects of multiple stud failures were studied in a finite element model of a typical highway bridge girder and revealed that the current design rules are overly conservative for all bridge classes in the Canadian Highway Bridge Design Code, and for all bridge configurations except for short spans. The results support the proposed new fatigue category dedicated to welded shear studs, recognizing the unique redundant and uninspectable nature of the detail, and suggest a fatigue endurance limit of 36 MPa (one and a half times the current limit). It is proposed that the embedded high strength bolt detail be viewed as a viable alternative to studs, given greatly increased fatigue performance and exceptional ease of deconstruction. The benefits of such a connection would be particularly useful in combination with precast deck panels.

Composite construction, using a reinforced concrete slab on top of steel girders, is an economical and popular form of construction for highway bridges. This book covers the design of continuous composite bridges, with both compact and non-compact sections, and simply supported composite bridges with the 'slab-on-beam' form of construction. Part One provides advice on the general considerations for design, the initial design process, and the verification of structural adequacy in accordance with BS 5400. The determination of design forces throughout the slab is described, and key features relating to slab design are identified. Advice on structural detailing is also given. Part Two provides worked examples for a four-span bridge, three-span bridge and for the deck slab of a simply supported bridge. Each example is presented as a series of calculation sheets, with accompanying commentary and advice given on facing pages. Design Guide for Composite Highway Bridges is a compilation of guidance previously given in separate SCI publications. As such it will act as an authoritative guide for new designers and as a reference text for the bridge design office.

Analysis and Design
A Simplified Approach
The Investigation of the Timber Concrete Composite Bridge Decks Design
Design of Modern Highway Bridges
Design of a Simply Supported Composite Highway Bridge

In recent years, bridge engineers and researchers are increasingly turning to the finite element method for the design of Steel and Steel-Concrete Composite Bridges. However, the complexity of the method has made the transition slow. Based on twenty years of experience, Finite Element Analysis and Design of Steel and Steel-Concrete Composite Bridges provides structural engineers and researchers with detailed modeling techniques for creating robust design models. The book’s seven chapters begin with an overview of the various forms of modern steel and steel–concrete composite bridges as well as current design codes. This is followed by self-contained chapters concerning: nonlinear material behavior of the bridge components, applied loads and stability of steel and steel–concrete composite bridges, and design of steel and steel–concrete composite bridge components. Constitutive models for construction materials including material non-linearity and geometric non-linearity The mechanical approach including problem setup, strain energy, external energy and potential energy), mathematics behind the method Commonly available finite elements codes for the design of steel bridges Explains how the design information from Finite Element Analysis is incorporated into Building information models to obtain quantity information, cost analysis

Innovative Bridge Design Handbook: Construction, Rehabilitation, and Maintenance, Second Edition, brings together the essentials of bridge engineering across design, assessment, research and construction. Written by an international group of experts, each chapter is divided into two parts: the first covers design issues, while the second presents current research into the innovative design approaches used across the world. This new edition includes new topics such as foot bridges, new materials in bridge engineering and soil-foundation structure interaction. All chapters have been updated to include the latest concepts in design, construction, and maintenance to reduce project cost, increase structural safety, and maximize durability. Code and standard references have been updated. Completely revised and updated with the latest in bridge engineering and design Provides detailed design procedures for specific bridges with solved examples Presents structural analysis including numerical methods (FEM), dynamics, risk and reliability, and innovative structural typologies

The latest in bridge design and analysis—revised to reflect the eighth edition of the AASHTO LRFD specifications Design of Highway Bridges: An LRFD Approach, 4th Edition, offers up-to-date coverage of engineering fundamentals for the design of short- and medium-span bridges. Fully updated to incorporate the 8th Edition of the AASHTO Load and Resistance Factor Design Specifications, this invaluable resource offers civil engineering students and practitioners a a comprehensive introduction to the latest construction methods and materials in bridge design, including Accelerated Bridge Construction (ABC), ultra high-performance concrete (UHPC), and Practical 3D Rigorous Analysis. This updated Fourth Edition offers: Dozens of end-of-chapter worked problems and design examples based on the latest AASHTO LRFD Specifications. Access to a Solutions Manual and multiple bridge plans including cast-in-place, precast concrete, and steel multi-span available on the Instructor's companion website From gaining base knowledge of the AASHTO LRFD specifications to detailed guidance on highway bridge design, Design of Highway Bridges is the one-stop reference for civil engineering students and a key study resource for those seeking engineering licensure through the Principles and Practice of Engineering (PE) exam.

Effective Slab Width for Composite Steel Bridge Members
Preliminary Design of a Composite Highway Bridge
Bridge Design and Evaluation
Distribution of Girder Loads in a Composite Highway Bridge
Based on AASHTO LRFD, Bridge Design Specifications

Combining a theoretical background with engineering practice, Design of Steel-Concrete Composite Bridges to Eurocodes covers the conceptual and detailed design of composite bridges in accordance with the Eurocodes. Bridge design is strongly based on prescriptive normative rules regarding loads and their combinations, safety factors, material properties, analysis methods, required verifications, and other issues that are included in the codes. Composite bridges may be designed in accordance with the Eurocodes, which have recently been adopted across the European Union. This book centers on the new design rules incorporated in the EN-versions of the Eurocodes. The book addresses the design for a majority of composite bridge superstructures and guides readers through the selection of appropriate structural bridge systems. It introduces the loads on bridges and their combinations, proposes software supported analysis models, and outlines the required verifications for sections and members at ultimate and serviceability limit states, including fatigue and plate buckling, as well as seismic design of the deck and the bearings. It presents the main types of common composite bridges, discusses structural forms and systems, and describes preliminary design aids and erection methods. It provides information on railway bridges, but through the design examples makes road bridges the focal point. This text includes several design examples within the chapters, explores the structural details, summarizes the relevant design codes, discusses durability issues, presents the properties for structural materials, concentrates on modeling for global analysis, and lays down the rules for the shear connection. It presents fatigue analysis and design, fatigue load models, detail categories, and fatigue verifications for structural steel, reinforcement, concrete, and shear connectors. It also covers structural bearings and dampers, with an emphasis on reinforced elastomeric bearings. The book is appropriate for structural engineering students, bridge designers or practicing engineers converting from other codes to Eurocodes.

Finite Element Analysis and Design of Steel and Steel-Concrete Composite Bridges, Second Edition is brought fully-up-to-date and provides structural engineers and researchers with detailed modeling techniques for creating robust design models. The book's eight chapters begin with an overview of the various forms of modern steel and steel–concrete composite bridges as well as current design codes (American, British and Eurocodes). This is followed by self-contained chapters concerning: nonlinear material behavior of the bridge components, applied loads and stability of steel and steel–concrete composite bridges, and design of steel and steel–concrete composite bridge components. The book's final chapter focuses on finite element analysis and design of steel-concrete composite bridges with profiled steel sheeting.The book will be a valuable reference source addressing the issues, problems, challenges, and questions on how to design a composite highway steel bridge with profiled steel sheeting as well finite element modeling of the bridge components. Provides all necessary information to understand relevant terminologies and finite element modelling for composite bridges Discussed new designs and materials used in highway and railway bridge Illustrates how to relate the design guidelines and finite element modelling based on internal forces not only on nominal stresses Explains what should be, the consistent approach when developing nonlinear finite element analysis for composite bridges Contains extensive case study on finite element analysis and design of steel-concrete composite bridges with profiled steel sheeting

Design Guide for Composite Highway BridgesCRC Press
Design of Structural Steelwork
Simplified LRFD Bridge Design
Design of a Continuous Plate Girder Highway Bridge with Composite Slab
Modular Timber Concrete Composite System for Short Span Highway Bridges
Design and Behavior of High Performance Steel I-girders with Composite Webs

An innovative concept for a modular timber concrete composite system for short span highway bridges has been designed and key components experimentally validated. The proposed system consists of a Ultra-High Performance Fibre Reinforced Concrete(UHPFRC) deck and glue-laminated timer (glulam) girders linked to act compositely together by reinforcing steel bar shear connectors. This composite system has light, stable modules that can be rapidly constructed on site with less special equipment. Simple design checks indicate that the concept satisfies all serviceability limit state(SLS) and ultimate limit state(ULS) requirements of the Canadian Highway Bridge Design Code. Pull-out tests characterized the embedment lengths of 20M steel bar connectors to be 10 bar-diameters in UHPFRC. Push-off tests determined the embedment lengths of the same bars to be 30 bar-diameters glued into the timber girders. The slip modulus of the connectors is determined to be 67 kN/mm. The stiffness of the crosswise self-tapping screw connectors were tested and found to be structurally insignificant in this application. The excellent tensile and cracking properties of the reinforced UHPFRC deck was experimentally verified. A small amount of reinforcement would further improve the ductility of the UPHFRC deck system.

Worked Examples
Construction, Rehabilitation and Maintenance
Simply Supported Composite Plate Girder Highway Bridge
The Design of a Two Span Continuous Highway Bridge with Composite I-beam
Design of Trussed Girder Highway Bridge for Composite Action