BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
INSTRUCTION DIVISION

FIRST SEMESTER 2016-2017

Course Handout-Part II

02.8.2016

In addition to part I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. CE G533

Course Title: Advance Composite Materials for Structures

Instructor-in-Charge: SHAMSHER BAHADUR SINGH

Course Description

This course deals with the composite material characteristics and application of innovative Fiber Reinforced Polymeric Materials (FRP) for reinforcement and strengthening of concrete structures. Overall, this course comprises of development history of FRP materials, FRP material characteristics, and manufacturing details. Furthermore, analysis and design of structures such as beams, bridge girders, and columns reinforced and/or strengthened with FRP materials are introduced. In addition, special topics such as seismic retrofitting of columns and analysis of FRP prestressed bridge girders with case study problems are also presented and described. This course will also consists of working on a term project on FRP composite structures leading to possible research publication.

Scope and Objective of the Course

Advance Composite Materials for Structures is an advance course for Graduate and Postgraduate students of structural and infrastructure engineering. The clear understanding of mechanics of solids and RCC design is prerequisite for this course. The primary objective of the course is to make students understand the characteristics and mechanics of fiber reinforced polymeric materials and apply these concepts for the analysis and design of structures reinforced and/ or strengthened with these materials. Moreover, students will learn the concept of design of FRP prestressed bridge girders. At the end of course, students will have the basic concepts of mechanics of composites and FRP material characteristics which will make them capable of tackling the problems related to analysis and design of FRP beams, FRP strengthened and/ or prestressed concrete structures.

PREREQUISITES: (1) Course No. CE F211: Mechanics of Solids
(2) Course No. CE F 311: Design of Concrete Structures

Text Books (TB)

1. Analysis and Design of FRP Reinforced Concrete Structures, Shamsher Bahadur Singh, McGraw Hill Education (India) Private Ltd., New Delhi, 2014, 323 pp.

Reference Books (RB)

1. Mechanics of Composite Materials, Robert M. Jones, Taylor and Francis, New York, London, 1999, First Indian Reprint, 2010, 519 pp.
2. Reinforced Concrete Design with FRP Composites, Hota V.S., Gangarao, Narendra Taly, and PV Vijay, CRC Press (Taylor & Francis Group), Boca Raton, FL, USA, 2007, 382 pp.
3. FRP Strengthening of RC Structures, Teng, J. G., Chen, J. F., Smith, S. T. and Lam, L. (authors), John Wiley & Sons Ltd., West Sussex, England, 2002, 245 pp. (E-mail: cs-books@wiley.co.uk; http://www.wiley.com).
4. Strengthening of Reinforced Concrete Structures using Externally Bonded FRP Composites in Structural and Civil Engineering, L. C. Hallaway and M. B. Leeming (editors), Woodhead Publishing Ltd., Cambridge England, 2001, 327 pp.
5. Mechanics of Composite Structures, Laszlo P. Kollar and George S. Springer, Cambridge University Press,New York, USA, 2003, 480 pp.

COURSE PLAN

Lecture No.	Learning Objective	Topics to be Covered	Reference Chapter/Sec. # (Book)
1-2	Introduction	Evolution of FRP Reinforcement, Description of fibers and resins, manufacturing and processing of composites, Mechanics of Composites	TB (Ch. 1),
3-9	Macromechanical Behavior of Lamina and Laminate and Micromechanical Behavior of lamina	Stress-strain relations for anisotropic materials, Engineering constants for orthotropic materials, strengths of orthotropic lamina, Mechanics of material approach to lamina stiffness and strength, The Halpin-Tsai Equations, Classical lamination theory.	RB1 (Ch. 2& 4), RB1 (Ch. 3)
10-11	Physical and Mechanical Properties	Density, Temperature Effects, Tensile strength and modulus, Compressive strength and modulus, Creep and creep rupture, Durability, Guaranteed strength and strain, Recommended materials and construction practices such as handling and storage of materials and quality control	TB (Ch.2)
12-16	Analysis of FRP Beams	Governing Equations, Boundary Conditions, Orthotropic beams, Rectangular Solid beams subjected to axial loads and bending, Stresses and strains, Thin-walled Open-Section Orthotropic or symmetrical cross-section beams subjected to axial load and bending	RB5 (Ch6)
17-21	Design of RC Structures Reinforced with FRP Bars	Flexural and shear Design Approach for FRP Reinforced RC Beams and FRP prestressed bridge girders, Strength Reduction Factors	TB (Ch.4)
22-31	Design Philosophy of FRP External Strengthening Systems	Failure modes and Typical Behavior, Design Approach for Flexural Strengthening, Strengthening Limits, Environmental and Strength Reduction Factors, Design with NSM FRP rebars, Serviceability checks, Design Examples	TB (Ch. 5)
32-36	Shear Strengthening	A method of External Shear	TB (Ch. 5)

	of Beams	Strengthening, Failure Modes, Shear strengthening using fabric sheets and NSM FRP rebars, Design Examples.	
37-42	External Strengthening of Columns and Seismic Retrofit	Methods of Strengthening, Failure Modes, Behavior of FRP-confined concrete columns, Compressive Strength of FRP-confined concrete, Design Models, Ultimate Strength of FRP-Confined RC Columns, Strength and Ductility Oriented Retrofit	TB (Ch.5)
43-44	Design Approach for CFRP Prestressed Concrete Bridge Girder	Case Study problem on Design of CFRP Prestressed Bridge Girder	TB (Ch.4)

Evaluation Scheme

EC No.	Evaluation Component	Duration	Weightage (%)	Date &Time	Remarks
1	Mid-Term Test	90 Min.	25	4/10 8:00 - 9:30 AM	Partially OB
2	Take Home Assignments	On Regular basis	10		OB
3	Special Projects* (Computer and Lab Oriented) Comprehensive Viva-Voce Examinations		20 (Term Paper) + 10 (Viva-Voce)	To be announced	
4	Comp. Exam	3 Hours	35	3/12 AN	Partially OB

Teaching Method: Teaching of the subject will be made by combination of power-point presentation and Blackboard writing. Most of the teaching will be based on blackboard writing. Necessary instructional materials (available and prepared by instructor) will also be supplied for ready reference.

*The term paper will be based on special project assigned to the students individually or in a group. The students will be working in consultation with instructor-in-charge. There will be two evaluations (1) Midterm report (10% weightage) (2) Final Report (10% weightage) in the form term paper followed by comprehensive viva-voce examination (10% weightage).

(Instructor-in-Charge)