Course: Bridge Structures
a.y.: 2025/2026
Instructor: Prof. Gian Michele Calvi
T.A.: tbd
Date: 20/11/2025 – 19/12/2025
Classroom: Eucentre, meeting room first floor ("acquario")

Course Objective

To equip the students with a thorough understanding of design process of bridges, starting from conceptual design to detailed design of bridge components.
To help the student understanding the load flow mechanism of various applied loads, such as truck load, impact, horizontal braking/centrifugal forces, wind and seismic loads on bridges.

Course Content

Historical background of bridges and types. Review of principles reinforced concrete and prestressed concrete, steel-concrete composite structures. Design process. Construction methods. Review of applicable design codes. Structural analysis tools. Seismic performance and retrofit technologies. Investigation of bridge collapses and damages.

Course Learning Outcomes

The students are expected to be able to understand the load-carrying capacity of various types of bridges, upon learning the structural responses to different kinds of loads. They should be able to design standard short and medium span bridges, using with confidence existing codes of practice at the end of the course.

Textbook

There will be no textbook assigned for this course. Class notes and handouts will be sufficient.

Reference Books

Bridge Design: Concepts and Analysis, António J. Reis and José J. Oliveira Pedro / John Wiley & Sons 2019
The Design of Prestressed Concrete Bridges: Concepts and Principles, Robert Benaim / Taylor & Francis 2008
Seismic Design and Retrofit of Bridges, M. J. N. Priestley, F. Seible and G. M. Calvi / John Wiley & Sons 1996
Displacement-based seismic design of structures, M. J. N. Priestley, G. M. Calvi and Mervyn J. Kowalsky / IUSS Press 2007
Design of Highway Bridges: An LRFD Approach, Richard M. Barker, Jay A. Puckett / John Wiley & Sons 2013
Prestressed Concrete Design to Eurocodes, Prabhakara Bhatt / Taylor & Francis 2011
Design of steel-concrete composite bridges to Eurocodes, Ioannis Vayas and Aristidis Iliopoulos / Taylor & Francis 2014
Steel-Concrete Composite Bridges: Designing with Eurocodes, David Collings / ICE Publishing 2013

The art of seismic design, G. M. Calvi / IAEE 2024
Eurocode 1: Actions on structures – Part 2 : traffic loads on bridges / CEN

Software

Bentz E.: "Response 2000". User Manual. Department of Civil Engineering, University of Toronto, Canada. Toronto, March 2001. (http://www.ecf.utoronto.ca/~bentz/r2k.htm)
Seismosoft: "SeismoStruct - A computer program for static and dynamic nonlinear analysis of framed structures". 2018. (http://www.seismosoft.com/seismostruct)
Mazzoni et al.: "OpenSEES - The open system for earthquake engineering simulation", PEER, UC Berkeley, 2006. (http://opensees.berkeley.edu)
SAP 2000 (https://www.csi-italia.eu/software/sap2000/)
Midas (https://www.midasuser.com/en)

Homework assignments (HA)

1) Structural analysis: computation of influence lines, flexural analysis of prestressed concrete and steel-concrete composite sections
2) Conceptual design of a bridge: definition of constraints, choice of a structural type, load analysis, preliminary dimensioning of elements

Project Description

Design of a simple bridge (possibly in groups of students)
1) Detailed design of superstructure components: deck analysis (flexure, shear and torsion)
2) Detailed design of substructure components: pier, foundations, bearing, joints

Grading Policy

Homework Assignment 1: 10%
Homework Assignment 2: 15%
Project: 35%
Final Examination: 40%

Final exam

Friday, December 19th, 9 - 11

Course schedule

Date	Lecture hours From___To___	Tutorial hours From To___	Topic
25/11/2025	10 - 13		Introduction: evolution of design and construction practise
25/11/2025	14 - 17		Continuation evolution of design and construction practise
26/11/2025	10 - 13		Bridge types: simply supported and continuous beam, truss, arch, stayed and suspension bridges
26/11/2025		14 - 17	Review of influence lines, flexural analysis of prestressed concrete and steel-concrete sections. Presentation of HA1
26/11/2025	10 – 13		Loads on bridges: gravity, traffic, wind, earthquakes, collisions, currents, temperature
26/11/2025		14 - 17	Examples of solutions of bridge design
2/12/2025	10 - 13		Deck considerations: solution of indeterminate beams, influence lines and surfaces, pre-stressed beams, concrete box, steel-concrete composite
2/12/2025		14 - 17	Analysis tools. Collection of HA 1. Presentation of HA 2
3/12/2025	10 - 13		Design of piers and foundations
3/12/2025		14 - 17	Design of a bridge deck: flexure, shear, torsion, pre- and post-tensioning, steel-to-concrete connection
4/12/2025	10 – 13		Design of bearings and joints
4/12/2025		14 - 17	Design of foundation and pier systems. Presentation of group project. Collection of HA 2. Discussion of group projects
10/12/2025	10 – 13		Seismic design of bridges
10/12/2025		14 - 17	Design of bearings and expansion joints. Discussion of group projects
11/12/2025	10 - 13		Design of isolated bridges
12/12/2025		10 - 13	Examples of construction methods. Discussion of group projects
16/12/2025	10 - 13		Maintenance and degradation, assessment and strengthening
16/12/2025	14 - 17		Case studies of design, assessment and strengthening
17/12/2025		10 - 13	Summary of the course, Q&A, presentation of group projects
17/12/2025		14 - 17	Presentation of group projects
19/12/2025	9 - 11		Final exam