Bridge Design

Prof. Dr. W. Kaufmann

Spring Semester 2024

Bridge Design

Objectives, Content and Organisation

Learning Objectives

After successful completion of this course, the student should be able to:

- Define the main bridge design parameters and identify constraints and boundary conditions
- Explain the structural behaviour and peculiarities of today's most important bridge typologies
- Explain the main elements of bridges and their structural behaviour
- Define the relevant actions on bridges
- Dimension a standard bridge (pre-dimensioning by hand; dimensioning using computer-aided tools)
- Explain the most relevant bridge construction and erection methods
- Select an appropriate typology and conceive a convincing bridge for a site with its specific boundary conditions
- Name the most eminent bridge designers and their relevant works

Study and Reference Material

Primary Material:

[1] Kaufmann, W., *Bridge Design*, Lecture notes, ETH Zurich, 2019/20/21
(Basics of the lecture) → available online: concrete.ethz.ch

[2] Menn, C., *Prestressed Concrete Bridges*, Birkhäuser, Basel, 1990
Hirt, M., Lebet, J.P., *Steel Bridges*, EPFL Press, New York, 2013
} → available at ETH library (online resource)

[3] Swiss society of engineers and architects (SIA), standards 260-267, 269, with emphasis on:

- SIA 260 *Basis of Structural Design*, 2003 (Partial rev. 2013)
- SIA 261 *Actions on Structures*, 2003 (Partial rev. 2014)
- SIA 262 *Concrete Structures*, 2003 (Partial rev. 2013)
- SIA 263 *Steel Structures*, 2003 (Partial rev. 2013)
- SIA 264 *Steel-Concrete Composite Structures*, 2003 (Partial rev. 2014)

[4] Eurocodes, EN 1990-1999, with emphasis on:

- EN 1990:2002 *Basis of Structural Design*
- EN 1991-2:2003 *Actions on structures - Part 2: Traffic loads on bridges*
- EN 1992-2:2005 *Design of concrete structures - Part 2: Concrete bridges - Design and detailing rules*
- EN 1993-2:2006 *Design of steel structures - Part 2: Steel bridges*
- EN 1994-2:2005 *Design of composite steel and concrete structures – Part 2: General rules and rules for bridges*

Study and Reference Material

Supplementary References:

[1] Melan, J. & Steinman, D.B., *Theory of Arches and Suspension Bridges*, Clark Publishing Co., 1913

[2] Podolny, W. & Muller, J.M., *Construction and Design of Prestressed Concrete Segmental Bridges*, Wiley, 1982

[3] Leonhardt, F., *Bridges – Aesthetics and Design*, MIT Press, 1984

[4] Hambly, E.C., *Bridge Deck Behaviour*, E&FN Spon, London,1991

[5] Troitsky, M.S., *Planning and Design of Bridges*, Wiley, 1994

[6] Manterola, J., *Puentes - Apuntes para su diseño, cálculo y construcción*, Madrid, 2005

[7] Scheer, J., *Failed Bridges – Case Studies, Causes and Consequences*, Ernst & Sohn, 2010

[8] Gimsing, N.J. & Georgakis, C.T., *Cable Supported Bridges*, Wiley, 2012

[9] Rosignoli, M., *Bridge Construction Equipment*, ICE, 2013

[10] Keil, A., *Pedestrian Bridges – Ramps, Walkways, Stuctures*, DETAIL, 2013

[11] North American Codes and Standards:

- AASHTO LRFD Bridge Design Specifications
- CSA S6 – Canadian Highway Bridge Design Code

Reading assignments will be provided throughout the semester to supplement the lecture notes

Content

1. Introduction

2. Conceptual Design

3. Superstructure / Girder Bridges
- Bridge Deck
- Bridge Girder
- Structural Efficiency
- Modelling
  … Overview (Warping vs. Uniform Torsion)
  … Spine Model
  … Grillage Model
  … Slab Model
- Design and Erection

4. Support and Articulation

5. Substructure
- Abutments
- Piers
- Foundations

6. Arch Bridges

7. Frame Bridges

8. Special Girder Bridges
- Cantilever-Constructed Girder Bridges
- Truss Bridges
- Skew Bridges
- Curved Bridges

9. Cable-supported Bridges

Lectures will be supplemented with Colloquia, a Field Trip and Flipped Classrooms

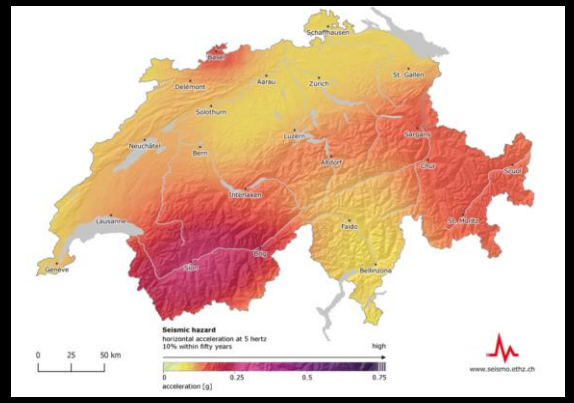
Seismic design and evaluation of bridges

Spring Semester 2024 (second half)

Tuesdays, 15:45-17:30
HIL D 10.2

Dr. Anastasios Tsiavos

→ Not covered in this class.



Ganter Bridge, Switzerland

Krk Bridge, Croatia

Rion-Antirion Bridge, Greece

Organisation

Lectures

- Tuesday & Wednesday, HIL E 3, 11:45-13:30
- Detailed semester program and lecture materials available online at https://concrete.ethz.ch/brd/

Exercises, Colloquium & Flipped Classroom

- Enhancement of the understanding of the topics discussed in the lecture
- Submission/participation optional, questions can be discussed during the consultation hours

Consultation hours

- HIL E 42.1 or online (Zoom) by appointment
- Assistant: Dr. Alejandro Giraldo Soto
- For questions concerning the lecture or the exercises

Exam

- Written, 180 minutes, English language
- Part 1 (Conceptual Design): 60 minutes; Part 2: 120 minutes

Prerequisites

The course is part of the MSc specialisation in structures and requires solid knowledge in structural analysis and design. Students are assumed to be proficient in the material taught in the following courses offered in the BSc in Civil Engineering at ETH Zurich (or have acquired equivalent knowledge elsewhere):

- Theory of structures I+II
- Steel structures I+II (incl. steel-concrete *composite* structures)
- Structural Concrete I+II (incl. *prestressed* concrete)

The flipped classroom exercises are preparing the students for Part 1 of the exam (conceptual design). Active participation is highly recommended to all students who have not conceived a bridge.

The exercises provided on the homepage and the colloquium prepare the students for Part 2 of the exam. It is highly recommended to try and solve these exercises during the semester. They can be handed in during the lecture or in HIL E42.1.

Field trip

Monday, 22.04.2024, 7.45 – 18.30 (ETH Hönggerberg)

St. Galler Brückenweg:

- Sitterviadukt der A1
- Hängesteg im Rechen
- Rürstenlandbrücke
- Kräzern-Strassebrücke
- SBB-Sitterviadukt
- SOB-Sitterviadukt
- Fachwerkbrücke Haggen-Stein