UNIVERSITÀ DEGLI STUDI DELL'AQUILA
CORSI DI INGEGNERIA

A.A. 2023/2024
Mechanics of bridges (I4C)
- D'Annibale Francesco - Masciocchi Silvio -

(Aggiornato il 2-08-2023)

Contenuti del corso (abstract del programma):

THEORETICAL LECTURES

- types of bridges;
- isotropic and orthotropic plates;
- discretization methods;
- profilati sottili;
- actions on bridges;
- analysis of local effects;
- girder bridges;
- box-girder bridges;
- mechanics of ropes;
- suspended bridges;
- cable-stayed bridges.

LECTURES ON NUMERICAL ASPECTS

Use of Finite-Element codes and semi-analytical methods to:

- build up the influence lines;
- to solve isotropic and orthotropic plates;
- analyze local effects;
- analyze the behavior of girder bridges;
- analyze the behavior of box-girder bridges.

LECTURES ON DESIGN ASPECTS (Silvio Masciocchi):

- presentation and discussion of the Bridge over the Po river in Piacenza, the Cable-stayed Bridge over the Garigliano, the Cable-stayed Bridge over the Tigris in Baghdad, the Morandi method for the design of cable-stayed bridges with prestressed cables;
- geometry of the bridge decks; loads, combinations and verify; secondary elements (joints, disposal of rainwater, flooring, waterproofing); support devices;
- road bridges: viaducts, single-span bridges, cable-stayed bridges;
- setting of the overall design of a viaduct and design choices for deck, piles and wing walls;
- pre-designing of a prestressed deck, a mixed steel-concrete section, in steel as an orthotropic plate.
- formation of designing groups and assignment of project work.

Programma esteso:

THEORETICAL LECTURES

- Types of bridges: Overview of static schemes of longitudinal and transversal bridges;
- Isotropic and orthotropic plates: of Mindlin and Kircchoff; considerations on torsional stiffness; geometric orthotropy and homogenization; plane grid with infinitesimal meshes.
- Discretization methods: Ritz, finite elements, finite strips, Generalized Beam Theory.
- Actions on bridges: dynamic effects due to transit, critical velocity of resonance; mass impacts on parapets and guard rails; braking and centrifugal forces; nonlinear thermal variations; prestressing; viscosity in structures with a static scheme variable over time and / or subject to constraining failures; seismic action.
- Analysis of local effects: models of isotropic shell or frame for reinforced concrete slabs; homogenized models of steel orthotropic shell, with single-field or multiple fields on elastic supports.
- Girder bridges: collaborative width (shear lag effect); finite elements of plane grid; approximate beam models: infinitely rigid transverse; Courbon method; Engesser method; surface of influence of the moment in the transverse; Massonet shell models.
- Box-girder bridges: unicellular: approximate model type GBT; multicellular: equivalent orthotropic shell model, shear deformable: connected by cross beams: beam model, by force method; connected by slab: approximate model with 'striped' slab and refined by finite macro-element of plate-shell; juxtaposed: model of adjacent hinged beams.
- Mechanics of Ropes: governing equations; catenary of the own weight; horizontal or inclined parabolic cable; apparent stiffness of suspended cables with sliding support; suspended cables subject to additional forces, with fixed or elastic supports; free oscillations of the cables.
- Suspended bridges: continuous model, flexural and torsional analysis of the bridge; notes of dynamics.

- Cable-stayed bridges: continuous model, flexural and torsional analysis of the bridge; notes of dynamics.

LECTURES ON NUMERICAL ASPECTS

- Influence lines: direct and indirect method; theorems of Betti, Maxwell and Land-Colonnetti.
- Analytical and numerical methods to solve isotropic and orthotropic plates, i.e., Mindlin and Kirchhoff, under different load conditions; considerations on the evaluation of torsional stiffness and examples; numerical examples of structures having geometric orthotropy and homogenization; examples on plane grid with infinitesimal meshes.
- Analytical and numerical modelling of the analysis of local effects: examples on models of isotropic shell or frame for reinforced concrete slabs, homogenized models of steel orthotropic shell, with single-field or multiple fields on elastic supports.
- Girder bridges: evaluation of the effective width (shear lag effect); finite elements of plane grid; approximate beam models: infinitely rigid transverse; Courbon method; Engesser method; surface of influence of the moment in the transverse; Massonet shell models.
- Analytical/numerical models of box-girder bridges: Unicellular, approximate GBT-like model; multicellular, examples on equivalent orthotropic shell model, shear deformable; connected by cross beams, examples on beam model, by force method; connected by slab, examples on approximate model with 'striped' slab and refined by finite macro-element of plate-shell; juxtaposed, examples on model of adjacent hinged beams.

LECTURES ON DESIGN ASPECTS (Silvio Masciocchi):

- presentation and discussion of the Bridge over the Po river in Piacenza, the Cable-stayed Bridge over the Garigliano, the Cable-stayed Bridge over the Tigris in Baghdad, the Morandi method for the design of cable-stayed bridges with prestressed cables;
- geometry of the bridge decks; loads, combinations and verify; secondary elements (joints, disposal of rainwater, flooring, waterproofing); support devices;
- road bridges: viaducts, single-span bridges, cable-stayed bridges;
- setting of the overall design of a viaduct and design choices for deck, piles and wing walls;
- pre-designing of a prestressed deck, a mixed steel-concrete section, in steel as an orthotropic plate.
- formation of designing groups and assignment of project work.

Modalità d'esame:

A first oral test, aimed at evaluating the assimilation of the theoretical contents of the course. A second oral test, to be carried out after the first, aimed at evaluating the ability to manage the tools of numerical analysis, illustrated during the course. A third oral test, to be performed before to the previous two, also on a different

day, which focuses on the discussion of the design work that the student will have produced with the assistance of an engineer, assigned to design exercises.

Risultati d'apprendimento previsti:

It is expected that the student, at the end of the course: (1) has sufficient mastery of the theory of bridges and of the analytical tools able to model the relative structures; (2) knows how to use numerical methods and tools and to critically analyze the results, recognizing the degree of reliability of the models used; (3) is able to draw up a preliminary draft of a bridge of medium difficulty.

Testi di riferimento:

Circolare applicativa n. 617 02.02.2009, Circolare Applicativa NTC 2018.

Lecture Notes

Mario P. Petrangeli, Progettazione e Costruzione di Ponti, CEA, IV edizione, 1996, Milano.