Title:

Design and analysis of cable and membrane structures

(36 hours in 12 weeks)

Instructor:

Ruy Marcelo de Oliveira Pauletti (Visiting Professor, University of São Paulo)

Course description:

This course focuses on the concepts required for the design and analysis of cables and membrane structures, comprising the basic elements of differential geometry required to properly express the problem of equilibrium of this type of structures, as well the main non-linear analysis techniques employed in their analysis, especially Newton's and Dynamic Relaxation methods. The problem of shape finding of this type of structures is presented, and the methods of Force Density and Natural Force Density Method are developed. Typical materials for cable and fabrics, connection details, design loads and safety criteria are also discussed. Students will learn how to identify the most appropriate analysis technique for a specific design problem, develop a deep understanding of the numerical algorithms, write their own numerical formulations for the displayed methods, apply available computer programs and apply their gained knowledge and skills in a project-based challenge.

Course objectives:

After having taken this course, students will be able to

- Understand the basic principles underlying the structural behavior of cable and membrane systems;
- Apply the main methods used for the structural analysis of prestressed systems;
- Apply the gained knowledge to the preliminary design of cable and membrane structures.

Syllabus:

1	Introduction. Basic concepts on cable and membrane structures.
2	Shape and equilibrium of 2D and 3D cables. Funicular shapes.
3	Nonlinear equilibrium of trusses and cable networks. Newton's Method. Finite Difference Approximations to Tangent Stiffness. Dynamic Relaxation Method. Force densities.
4	Elements of differential geometry. Differential equations of the equilibrium of membranes. Minimal shapes.
5	Argyris' natural approach for membrane elements. Wrinkling of membranes. Natural force densities for membranes.
6	Use of dedicated and general-purpose computer programs (Ansys, SATS, ix-Cube).
7	Design of cable and membrane structures. Material, fabrication, loads, safety factors, detailing - I
8	Design of cable and membrane structures. Material, fabrication, loads, safety factors, detailing - II
9	Project Assignments
10	Projects' Follow-Up
11	Projects' Follow-Up
12	Projects' Follow-Up and Evaluation

Recommended Reading:

- Pauletti, R.M.O., Guirardi, D.M., 'Implementation of a Simple Wrinkling Model into Argyris' Membrane Finite Element'. Textile Composites and Inflatable Structures VI - Structural Membranes 2013, edited by K.-U. Bletzinger;B. Kröplin; E. Oñate. e ed 1. Vol. 1, 142-153.
- Pauletti, R.M.O. , 'The Natural Force Density Method'. IABSE-IASS Symposium - Taller, Longer, Kighter IABSE-IASS Symposium - Taller, Longer, Lighter London, 2011
- Pauletti, R.M.O.; Pimenta, P.M. 'The natural force density method for the shape finding of taut structures'. Computer Methods in Applied Mechanics and Engineering, 2008
- Pauletti, R.M.O., 'Static Analysis of Taut Structures' Textile Composites and Inflatable Structures II. 1 ed. Eugenio Oñate ; Bernard Kröplin. (Eds.) Dorderecht: Springer-Verlag, 2008, v. 1, p. 117-139.
- Pauletti, R.M.O.; Guirardi, D.M. ; Deifeld, T.E.C. 'Argyris' Natural Membrane Finite element Revisisted'. Textile Composites and Inflatable Structures. Barcelona: CIMNE, 2005, p. 335-344.E. Oñate; B. Kröplin. (Org.).