OPTIMIZATION OF PRESTRESSED CONCRETE BRIDGES

Ecole doctorale Sciences Pour l'Ingénieur

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Introduction

Road infrastructure is the basis of communication and transportation systems in both developed and under development countries. With the increasing evolution of socio-economic activity and urban growth, the improvement of communications becomes an obvious necessity. The construction of bridges has, since then, become essential to cross new communication routes.

Prestressed concrete bridges are frequently used in the motorway design when intersecting traffic occurs. Durability, aesthetics and ease of construction and maintenance are some advantages to their use.

In the design of a prestressed concrete bridge deck, the analysis and the rearrangement of the cables represent a very important task.

Most traditional procedures for structural concrete design select initial solutions based on material grades and cross-section dimensions derived from common practice and previous experiences. Once the structure is defined, the analysis is carried. Should the dimensions or reinforcement be insufficient, the structure is redefined on a trial-and-error basis. This process is not automatic and leads to safe design, but the cost of the concrete structure is highly dependent upon the experience of the structural engineer.

Optimization methods are a clear alternative to experience-based methods!! Many researchers have been working in this direction, and it can be clearly stated that applying optimization techniques to the concrete structures design has made the structural design more efficient.

Methodology Adopted

The objective of this research project is the development of a digital tool for the optimization of two types of prestressed concrete bridges:

Continuous bridge (sur cintres)

Cantilever bridge (encorbellement)

This year's study was conducted for the continuous bridge "construit sur cintres".

METHODOLOGY IS DIVIDED INTO 2 PARTS:

- **PRESTRESSED CONCRETE BRIDGE DESIGN**
- **OPTIMIZATION PROBLEM DEFINITION AND RESOLUTION**

1-PRESTRESSED CONCRETE BRIDGE DESIGN:

Main steps followed and accomplished

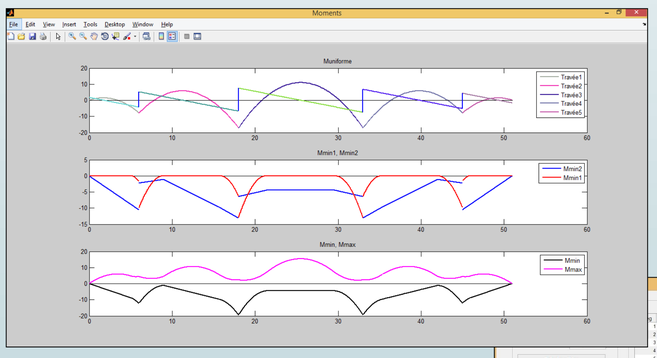
- **LOADING DEFINITION:** Given by the Eurocode EN-1991-2
- **ANALYSIS OF THE DECK** (tablier):
  - Longitudinally: the bridge is assumed a continuous beamlike structure supported on the piers. The analytical method consists of finding the envelop curves of the moment and shear under different load combinations, in order to design the bridge for the worst case
  - Transversally: the analysis of the transversal stress-resultants can be analyzed according to different methods (Guyon-Massonnet)
- **PRESTRESS ANALYSIS:** Computation of the prestressing force:
  - Concordant cable profile method: The cable layout is defined such that no secondary moments are developed in the continuous beam
- **PRESTRESSING LOSSES CALCULATIONS**

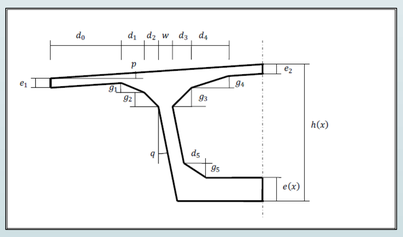
$$e_{oo} = \frac{M}{P} = e_o + \frac{M_{hyp}}{P}$$

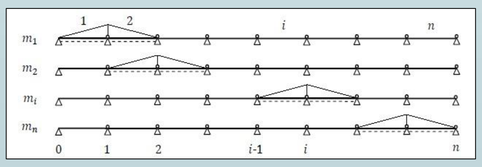
- **VERIFICATION OF STRESSES AT SERVICE STATE AND ULTIMATE STATE**

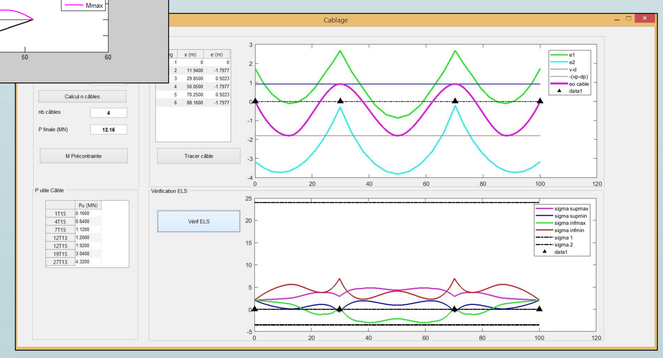
RESULTS OF PRESTRESSED CONCRETE BRIDGE DESIGN:

- Establishing an Excel and a Word written document of the applied analytical method for the cable definition and the prestressing force calculation for a 10 span continuous beam
- Programming this method into Scilab software









2-OPTIMIZATION PROBLEM DEFINITION AND RESOLUTION:

A literature review was conducted of the many published papers regarding the different optimization techniques adopted in the optimization of prestressed concrete bridge.

RESULTS:

Optimization problem can be stated in the following form:

Minimize {Cost of structure (Objective Function)}
While satisfying the constraints:
g1: Geometric constraints
g2: Serviceability limit states (deflection, stresses, …)
g3: Ultimate limit sates (Moment, shear, …)
g4: Tendon layout and configuration constraints
With the design variables:
-Geometric design variables (Structure dimensioning)
-Material strength
-Prestressing variables

Optimization methods can be divided into two main categories:

DETERMINISTIC OPTIMIZATION		STOCHASTICS AND METAHEURISTICS	
Kuhn-Tucker	Newton	Genetic Algorithm	Tabu Search
Simplex	Fibonacci	Simulated Annealing	Particle Swarm Opt
…		…	

PRESTRESSED CONCRETE BRIDGE OPTIMIZATION => NON LINEAR PROBLEM

RESOLUTION

LINEARIZATION AND SIMPLIFICATION OF THE PROBLEM => **SIMPLEX** **OR** **METAHEURISTICS**

What's Next?

MAIN TARGETS:

- ***Choosing the proper optimization technique for our problem***
- ***Listing all design variables and constraints***
- ***Apply the optimization problem to Scilab***
- ***Analyze results***
- ***Conduct parametric studies for the design variables***
- ***Jump to the Cantilever bridge analysis***