Monitoring of Bridges by Advanced Methods of Experimental - Mechanical Symbiosis

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Summary

Long-term monitoring is becoming a common tool of condition evaluation of bridges. The task is characterised by the application of a huge number of sensors of different types at the structure on the one hand, and on the other hand with the development of an adaptive structural model for the bridge to interprete all the measured data and provide a basis for their coupling. Although this task is of fundamental importance for the planning and monitoring as well as for the evaluation and interpretation of the experimental results, only small attention has been focussed on this subject as far as a systematic coupling in mathematical terms is considered. For the concrete bridges of the new main railway station of Berlin ("Lehrter Bahnhof"), a monitoring system has been developed in order to observe the deformations of the bridges due to settlement and heaving of the foundation during construction works in the direct neighbourhood with deep excavations and large new buildings, figure 1.

Keywords: long-term monitoring, sensors, experimental-analytical symbiosis, bridges Lagrangian Multipliers, structural modelling

1. Introduction

Monitoring of structures right from the beginning become a more and more common task. New types of structures and materials require an observation of the structure's behaviour starting from its erection. Together, the complexity of advanced structures suggests an observation to disclose a possible misbehaviour of the structure to detect its causes.
The task of bridge monitoring demands a mathematically based method for the symbiosis of all the measured data in view of the structural system.
The aim of the newly developed method was the combination of all measured data in one physical (mechanical) system which is based on the structural system of the bridge. Of great importance was the easy understanding of the method, and this was the prior reason for starting from the *Finite Element Method.* The different steps of solving the problem are:

- mechanical modelling (e. g. beam bending theory for simplicity)
- discretisation (finite elements)
- mathematical modelling by applying Hermitian Polynomials (of first order) as shape functions
- the Gaussian least squares method as related variational principle which allows to add the constraints from the structural system as side equations (constraints) with Lagrangian Multipliers.

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